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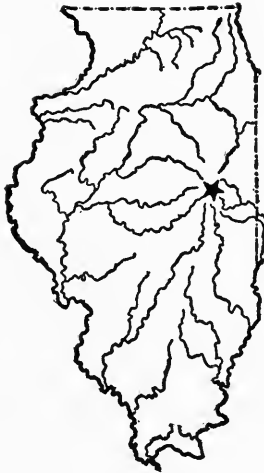
BULLETIN No. 293

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ADJUSTING HOG PRODUCTION  
TO MARKET DEMAND

IN COOPERATION WITH THE BUREAU OF  
AGRICULTURAL ECONOMICS, U. S. DEPARTMENT OF AGRICULTURE

By F. F. ELLIOTT



URBANA, ILLINOIS, JUNE, 1927

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# ADJUSTING HOG PRODUCTION TO MARKET DEMAND

By F. F. ELLIOTT, Formerly Associate in Farm  
Organization and Management<sup>1</sup>

Illinois farmers produce and send to market each year from 4 to 6 million hogs. These hogs return to their owners on an average a gross annual income of 75 to 100 million dollars. In addition to being the chief direct source of income on many farms, hogs furnish year in and year out probably the best market for the corn crop, which is the principal crop grown. They also provide a market for waste and low-grade grains, legume forages, and other feeds which likely would be less profitably utilized by other means, if at all. It is apparent, consequently, that anything which affects the profitableness of hog production is of vital concern to the Illinois farmer.

There are many things which determine the profitableness of the hog enterprise. Some have to do with production methods, others with time of marketing, changes in demand and supply, adjustments in production, and so forth. While fully recognizing the importance of adopting efficient methods and practices, the present bulletin is concerned primarily with an analysis of the factors which cause fluctuations in demand for hogs, and the importance of keeping production adjusted to changing conditions of the market.

The periodic gluts and depressions of the market at the present time are one of the great handicaps to profitable hog production. This is a condition which producers themselves can do much to remedy. It is well known that when the price of hogs is high in comparison with the price of corn there is a tendency to go into hog production too heavily, production is increased too far and an oversupply results. The surplus causes a sharp decline in price. With low prices prevailing, the majority of producers tend to reduce their hog production too much. They cut down too drastically just as they increase too far when prices are favorable. This in turn leads inevitably to a relative scarcity of hogs, and the price increases considerably. This favorable situation does not continue very long, however, until farmers again begin to increase their production, and in a short time, usually fifteen to eighteen months later, the supply is more than adequate to meet the demand, and the price falls again.

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<sup>1</sup>Mr. Elliott is now Agricultural Economist, Bureau of Agricultural Economics, U. S. Department of Agriculture.

Before producers can adjust their production with any degree of success to market demand and avoid periods of overproduction, they must first have some knowledge of the factors that bring about market changes and how these factors operate. Parts I and II of this bulletin are designed to throw light upon this subject and to indicate specifically the more important factors which determine the price and supply of hogs. Part III shows how farmers in Illinois have responded to the principal factor affecting production, namely, the corn-hog ratio. Part IV seeks to answer the question, What can the Illinois farmer do to help stabilize market conditions and thereby make hog production a more profitable part of the farm business?

## PART I WHY HOG PRICES FLUCTUATE<sup>1</sup>

During the past few years the Illinois farmer has seen rather wide fluctuations in the price of his products. These fluctuations have not been confined to any one product tho some have fluctuated more widely than have others. Fig. 1 shows the monthly fluctuations in the price of heavy hogs at Chicago from 1904 to 1925. Were the chart enlarged to include prices for even earlier years, the same general movements would be exhibited.

Three fairly distinct movements in the price of hogs are discernible. These price movements may be designated as: (1) trend movements, (2) seasonal movements, (3) cyclical movements.

**Trend of Hog Prices.** Probably the most noticeable of these movements in the price of hogs, apart from the striking upward bulge from the latter part of 1916 to the middle of 1920, is the gradual upward tendency thruout the greater portion of the period covered by the chart. Whereas the average monthly price was \$5.05 per 100 pounds for the year 1900, it was \$8.51 for 1924.

It would not be accurate to conclude from these figures, however, that the hog producer necessarily was better off in 1924 than he was in 1900. Before it is possible to arrive at an accurate conclusion it is necessary to know the relative purchasing power of the dollar at the two

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<sup>1</sup>The discussion of why hog prices fluctuate is based largely on the statistical analysis of hog prices made by Messrs. Ezekiel and Haas of the Bureau of Agricultural Economics, U. S. Department of Agriculture, as published in Department Bulletin No. 1440, "Factors Affecting the Price of Hogs." The writer wishes to express to them and to Mr. H. R. Tolley, of the Bureau, his appreciation for many helpful suggestions and criticisms both on this section and on other parts of the bulletin.

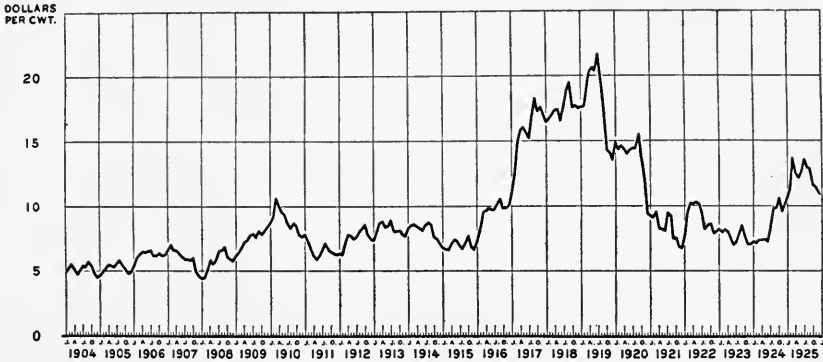


FIG. 1.—MONTHLY AVERAGE PRICE OF HEAVY HOGS AT CHICAGO FROM 1904 TO 1925

Note (1) that the level of the price is higher at the end of the period than at the beginning, that is, that the general trend of price has been upward; (2) that prices move up and down in successive swings over a period of years, or in what is known as price cycles; and (3) that they tend to be high in the spring and fall each year and low in the summer and winter, these variations being known as seasonal movements.

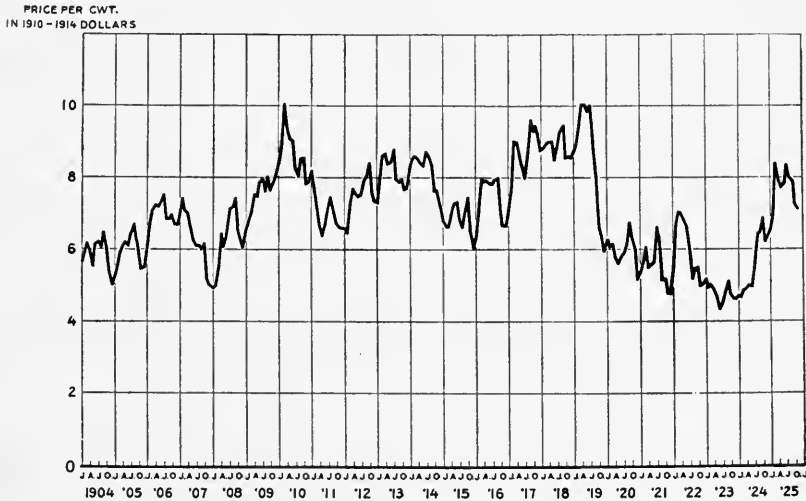


FIG. 2.—PRICE OF HEAVY HOGS AT CHICAGO FOR 1904 TO 1925 EXPRESSED IN TERMS OF 1910-1914 DOLLARS

The producer is more interested in knowing what the price of hogs is in terms of what his dollars will buy than he is in knowing merely the money price. This chart has therefore been arranged to show how hog prices have fluctuated since 1904 after changes due to the changes in the value of money have been taken out. The correction was made by dividing each monthly price by the index of all commodities for that month.

periods. By the purchasing power of the dollar is meant the amount of "all commodities" which it will buy. It is customary to take the purchasing power for some pre-war period, such as from 1909-1914, as normal or 100. Upon this basis the dollar in 1900 had a purchasing power of 121.9, and in 1924, 65.6. Or to state it another way, the dollar in 1924 would have purchased in all commodities only 53.7 percent as much as in 1900. Applying this fact to the price of hogs we find that the returns from 100 pounds of live hogs in 1900 (\$5.05) would have purchased as much as would the returns from 110 pounds in 1924 (\$9.36).

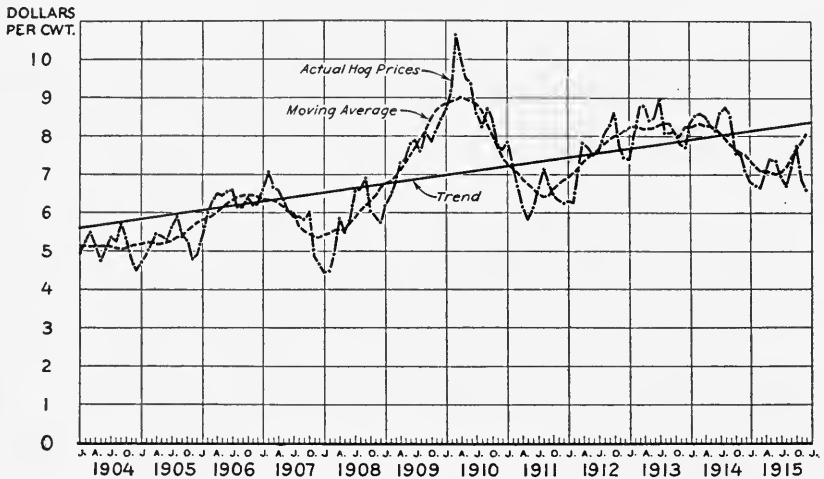


FIG. 3.—ACTUAL HOG PRICES FROM 1904 TO 1915 WITH VARIATIONS DUE TO SEASON ELIMINATED IN THE MOVING AVERAGE

This graph shows how prices swing first above and then below the long-time trend, the trend being represented by the straight line and the cycles by the moving average.

Fig. 2 shows how the monthly price of heavy hogs at Chicago from 1904 to 1925 has varied when expressed in terms of the 1910-1914 dollar, or in terms of a dollar with constant purchasing power. It is apparent that the trend in hog prices has been upward for most of the period. While it was downward from 1919 to 1923, it turned upward again in 1924.

**Seasonal Movements in Hog Prices.** The monthly fluctuations in hog prices appear to be of a very irregular nature. Close examination, however, reveals a fairly definite and clearly discernible movement from one month to the next and from season to season. Thus hog prices are usually higher in April and September than in June and December;

higher in the spring and fall than in the summer and winter. This seasonal movement must be taken into account when comparison is made between prices at different periods of the year.

**Cyclical Movements in Hog Prices.** A third movement of hog prices which is clearly discernible from Fig. 1 is the tendency for periods of high and low prices to follow each other at fairly definite intervals. This tendency for the price to swing up and down in cycles has come to be designated as the "hog-price cycle." During the past twenty-five years these up and down swings have had a duration of around three years, altho they sometimes have extended over a shorter period and sometimes a longer one. Prices swing downward usually for a period of 18 to 24 months and then reverse themselves for about the same period. The moving average in Fig. 3 shows the cyclical movements in hog prices after the trend and seasonal movements have been taken out.

In the discussion which follows attention will be confined to the most important factors determining the price of hogs. The analysis will begin by considering the factors influencing the demand for hogs.

## INFLUENCE OF VARIOUS DEMAND FACTORS ON PRICE

### The Demand of the Consumer

Stated in the simplest terms it may be said that what the consumer will pay, or can be induced to pay, for pork and pork products will determine what the buyers of live hogs can pay. That the buyers of live hogs can pay no more than this and stay in business is obvious. It is also evident that they cannot pay even this much, since their operating and overhead expenses, as well as any margin they receive for doing business, must all come out of the price the consumer pays.

Consumers as such have no direct demand for live hogs but they do have a demand for the dressed cuts of meat. They indicate this demand to their retailers by being willing to buy a certain amount of meat or meat products at a given price. If they are willing to buy a larger amount at the same price or the same amount at a higher price, the retailers conclude that their demand is increasing and indicate this fact by placing larger orders for meat or offering higher prices for it. On the other hand, if consumers do not indicate a willingness to purchase the usual amount of meat or meat products at the prevailing prices this fact also is soon relayed back to the central markets and likewise will be reflected in the price of live hogs.

Of course this process does not work quite so simply as stated here. High retail prices are not *immediately* reflected in high prices of live hogs in the central markets, tho they ultimately will be so expressed.

Neither will the producers of hogs necessarily get the entire benefit of the increased demand. The retail and wholesale agencies operating between the consumer and the producer also receive a part of the benefit.

That there is a very close correspondence between the movement of the prices of live hogs and the dressed cuts of meat will be noted from Fig. 4. The margin, however, between the wholesale and

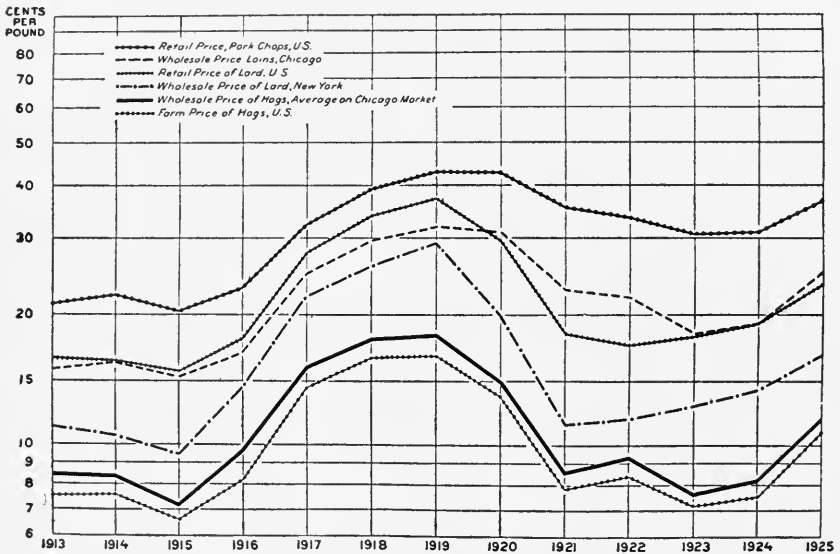


FIG. 4.—FARM AND MARKET PRICES OF HOGS AND WHOLESALE AND RETAIL PRICES OF PORK AND LARD FROM 1913 TO 1925

The prices of pork products at each step from farmer to consumer are shown in this chart. While prices for the various products tend to move together thruout the period shown, in some years prices for certain of the dressed products, such as pork loins, moved up, while those of some of the other products moved down.

retail prices has varied somewhat from year to year. This would be expected since the costs of capital, labor, materials, etc., vary, and do not necessarily increase or decrease with the prices of the products into whose production they enter.

There are many factors which by influencing the demand for pork and pork products influence the demand for live hogs. These are, (1) the price of substitute products, (2) general business conditions, (3) storage holdings, (4) pork exports or foreign demand, (5) increase in population. Each of these factors needs further discussion.

### **Price of Substitute Products**

Consumers vary widely in their wants and consumption habits. They also vary widely in their incomes and purchasing power. As a result they assign different degrees of importance to goods. Pork and pork products, for example, will be purchased by people with large incomes regardless of how high the price goes. In the lower income groups, however, with people who have to make each dollar go as far as possible, the height of the price has a good deal to do with how much they will buy. If pork prices get out of line with other prices, they will substitute either beef or mutton, dairy products, or possibly consume more fruit and vegetables. So one of the first factors that influences the demand for pork and pork products is the price of substitute products.

### **General Business Conditions**

As would be expected, there is a fairly close relationship between the demand for hogs and the general level of prosperity of the business community. When business is active, employment steady, and wages high, each individual consumer has more income to spend. He reflects his increased prosperity by purchasing more freely of all products, pork products included. These increased purchases, whether resulting from purchasing more pork and pork products at the same price or the same amount at higher prices, represent an increased demand. This increased demand for the dressed cuts will be passed back by the retailers to the wholesalers and packers, and will eventually be reflected in the price of live hogs in the same way as was explained previously.

### **Storage Holdings of Pork and Pork Products**

There is considerable variation in the receipts of live hogs at the central markets; consequently there necessarily is some variation in slaughter from day to day and month to month. All the hogs that are slaughtered are not immediately sent into consumption channels, but the excess slaughter from day to day and week to week is carried over and held in storage for later consumption. Thus storage provides the means and performs the important function of insuring an adequate supply of pork and pork products at the particular time and in the exact form desired by the consuming public.

To the man who has live hogs to sell large storage supplies act as a check upon demand. He will find that the buyers in the central markets will not be disposed to bid very high for live hogs when the supply available is adequate to take care of ordinary consumption needs. On the other hand, if the amount of pork and pork products is low and the

demand for these products, as indicated by retail orders, is steady or increasing, the buyers of live hogs will be inclined to buy more heavily, and in order to insure that an adequate supply will be forthcoming will offer higher prices if necessary to get them.

### Foreign Demand for Pork and Pork Products

The total production of pork and pork products in the United States is normally much larger than is needed for domestic consumption. A considerable portion of our production consequently must depend upon foreign markets for an outlet. Most of this excess production is taken by the countries of Western Europe.

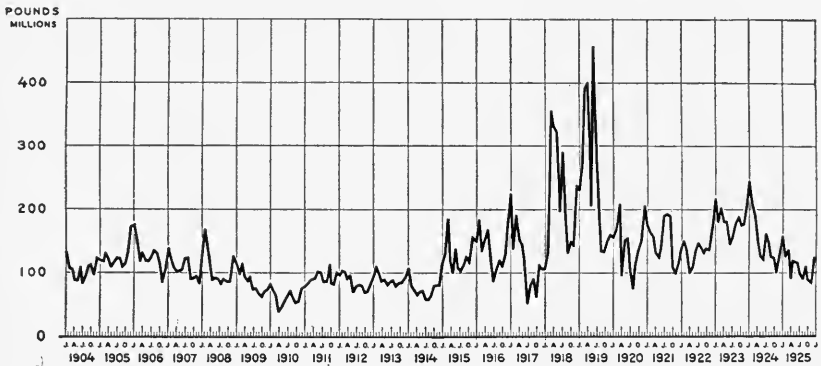


FIG. 5.—MONTHLY EXPORTS OF HOG PRODUCTS FROM 1904 TO 1925 IN TERMS OF POUNDS OF PORK OR EQUIVALENT

The various pork products were thrown into an index and weighted according to the relative prices at which each sold for export from 1910 to 1914. Using pork as a base and giving it a weight of 100, lard had a weight of 103, bacon 119, hams and shoulders 122.

We normally export about one-sixth of our total production of pork and pork products. In the year 1924 this class of exports amounted to the enormous total of 1,933 million pounds. This compares with a five-year post-war (1920-1924) average export total of 1,705 million pounds and a five-year pre-war (1910-1914) average export total of 911 million pounds. These totals include exports of fresh, canned, and pickled pork, cured hams and shoulders, bacon, lard, and neutral lard. Of these totals, lard and cured pork comprize the major portion. In Fig. 5 are shown these monthly exports of pork and pork products from the United States in the period from 1904 to 1925. These are expressed in terms of a general index into which the various products have been thrown and weighted



according to the average price at which each sold for export during the period 1910 to 1914.<sup>1</sup>

Foreign buyers indicate their demand for pork and pork products by being willing to take a certain quantity at a given price. If they are willing to take more at the same price or the same amount at a higher price, the American seller will consider that their demand is increasing and will indicate this fact either by passing on larger orders or by offering higher prices. If storage holdings are large, this increased foreign demand will first be met by pulling some of these storage stocks into consumption. Sooner or later, however, these larger stocks in storage will become depleted, and in order to fill the incoming orders the buyers of hogs will go into the market and make heavier purchases of live hogs. Thus the increased foreign demand is reflected in the price of live hogs.

Whether the foreign demand for pork and pork products at any particular time is high or low will be determined by a number of things, the chief of which are the purchasing power of the foreign consumer, general business conditions in foreign countries, the relation between the price of pork and pork products and the price of substitute products in foreign markets, as well as all the other intricate and puzzling factors which influence international trade, such as exchange rates, tariffs, governmental policy, etc.

### **Increase in Population**

An additional major factor which influences the demand for pork and pork products and thereby for live hogs is that of increase in population. This factor is especially important when attempting to explain the difference in price over a period of years or in attempting to ascertain what prices will be in the future.

During the past decade our population increased about 15 percent. In previous decades the increase was even more rapid. This increase in population means more people to feed; hence increased quantities of pork products are required if per capita consumption is to be maintained. While the per capita consumption of pork products varies from year to year and from cycle to cycle, with the exception of a slight downward trend it has been maintained at a fairly stable level since 1900. In the same period the trend in the prices of hogs in terms of purchasing power has been decidedly upward. Apparently consumers have been willing to pay higher prices for the same quantity; which means, of course, an increased demand.

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<sup>1</sup>Using pork as a base and giving it a value of 100, lard had a weight of 103; bacon, 119; ham and shoulders, 122.

The influence which such an increase in demand will have upon the price of hogs will be determined by the rapidity with which the supply will be increased to meet the demand. If the demand increases faster than the supply, then its influence will be reflected in an upward trend in price. If supply increases more rapidly than demand, then the opposite effect will result and we shall have a downward trend in price.

#### HOW THE SUPPLY OF HOGS AFFECTS PRICE

Up to this point the analysis has been confined to a discussion of the circumstances which influence the demand for live hogs and their effect on price. Nothing has been said about the influence which the supply of hogs, the most important single factor, exerts upon price.

Considering supply as one total factor balanced against all the factors that go to make up demand, we find what we should expect to be true, namely, that when the supply is large the price is low, and when the supply is small the price is high (Fig. 6). While this relationship is

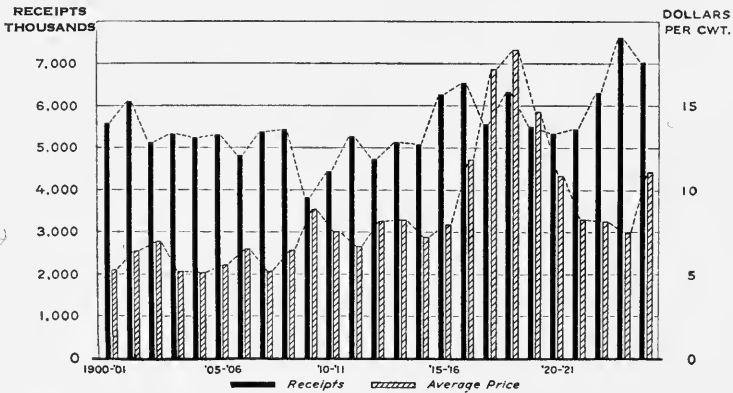


FIG. 6.—CHANGES IN RECEIPTS AND IN PRICE OF HOGS AT CHICAGO FROM SEPTEMBER TO APRIL OF EACH YEAR, 1900 TO 1925

When production is low the price is high, and when production is high the price is low.

clearly defined even in weekly receipts and prices, it is much more distinctly shown over a longer period. This is because buyers of live hogs will not be influenced to bid very high by a temporary shortage of hogs on a particular daily or weekly market if they think there are large numbers still on farms which will soon come to market.

Daily, weekly, and seasonal fluctuations in the supply of hogs are due to a number of circumstances such as the nature of the hog enterprise, the conditions under which hogs are raised and fattened, and variations in farmers' resources and their reactions to market conditions.

The great bulk of hogs produced in the United States come from the corn-belt states of the Middle West. In this section the winters are rather long and severe. This makes winter hog production probably more uncertain and expensive than summer production. More expensive buildings and equipment and better care are required when pigs are farrowed in the winter. Also more feed is likely to be required to produce a given gain in the winter time. This is particularly true with the conditions under which the majority of farmers produce hogs. These and other considerations probably have been the main reasons why farmers in the corn belt plan to have the major portion of their pigs farrowed in the spring or summer months. Having a large amount of corn available, they push the pigs and plan to market them when they are 6 to 9 months old. This accounts for the large receipts in the later fall and winter months and explains why receipts are low in early fall and spring.

Variations in receipts from day to day and week to week arise because farmers do not interpret a given market situation in the same way, and because they are producing under different conditions and financial circumstances. A temporary rise in price may cause some farmers to hurry their shipments in an attempt to take advantage of the favorable market. Other farmers under the same circumstances will hold on longer and feed out to heavier weights. It is things like these that cause short-time fluctuations in receipts and in prices.

#### RELATIVE IMPORTANCE OF THE VARIOUS PRICE FACTORS

In the foregoing pages the factors determining the price of hogs have been enumerated and discussed. No pretense is made that these are the *only* factors influencing the price of hogs. No doubt there are a good many others which have a slight influence, some of them capable of statistical measurement and others not. The influence of all these other factors, however, is relatively insignificant as compared with the important influence of those here discussed, amounting probably to less than 15 percent.

Supply of hogs (including storage holdings) is the most important single factor in determining the price of hogs. Increases in population and changes in the value of money are next in importance, followed by foreign demand for pork products, the price of substitute products, and general business conditions.<sup>1</sup>

This brings us to the next question, What causes the *supply* of hogs to fluctuate? This is discussed in Part II, which follows.

<sup>1</sup>Using these factors and correlating them with the price of hogs, Ezekiel and Haas, in U. S. Department of Agriculture Bulletin No. 1440, were able to account for approximately 88 percent of the total monthly variations in the price, leaving only 12 percent unaccounted for, which is of negligible importance as compared with the total.

## PART II

### CAUSES OF YEARLY FLUCTUATIONS IN THE SUPPLY OF HOGS

We have noted briefly some of the causes for short-time fluctuations in the supply of hogs. We may now consider long-time fluctuations and ask why it is that a large supply of hogs is produced one year and only a year or year and a half later a supply not nearly so large. The answer to this question will involve a discussion of all the factors which farmers take into consideration when they begin to breed for the market. Daily and weekly fluctuations are market phenomena and have to do with the manner in which the supply is disposed of *after it is in existence*. These other factors go further and explain why there is a supply in the first place, and why it is larger at one time than it is at other times.

Now in this connection the reader must bear in mind that we are attempting to get at the factors which the *mass* of farmers take in consideration when they go into hog production. It is not assumed that *all* farmers are actuated by the same considerations, or that they are influenced to the same degree by any one factor. Each farmer will interpret a given situation in the light of his own knowledge, experience, and peculiar conditions; but since it is impossible to make a separate study of the factors which each individual farmer takes into consideration in his production of hogs, attention must be confined to an analysis of those which the *majority* of farmers consider.

Taking receipts of hogs at Chicago as a measure of the supply from year to year, an analysis was made of the relative effect of a large number of factors upon receipts. Some ten to fifteen in all were considered, among which the following were included: the relation between corn and hog prices; the relation between hog and steer prices; size of the merchantable corn crop or percentage of non-merchantable corn; number of breeding sows on farms; loss from disease; climatic conditions at farrowing time; trend in production, etc.

A question may here arise in the minds of some readers whether the above factors really represent all the important ones that influence receipts. Since oats, barley, and wheat to some extent are used as feeds for hogs at certain times, also tankage and mill feeds, the reader may be wondering why an oats-hog ratio, barley-hog ratio, wheat-hog ratio, etc., were not considered. When the analysis was made, these ratios *were* taken into consideration but they were not used as independent factors because it was assumed that there was such a high correlation between them and the corn-hog ratio that when the intercorrelations were corrected for, their net influence would be nil. Subsequent statis-

tical analysis confirmed this hypothesis (see Statistical Appendix).

All these factors likely to influence receipts may be divided into three main groups: those influencing a farmer's *inclination* to go into hog production, those influencing his *ability* to go into the enterprise, and those which tend to *work against* or to defeat his efforts.

## FACTORS THAT INFLUENCE A FARMER'S INCLINATION TO GO INTO HOG PRODUCTION

### Corn-Hog Ratio One of First Factors

Farmers in Illinois and most of the other corn-belt states begin to breed their sows for spring litters around December 1, tho many sows are bred in November and also in January. What are the things they take into consideration when they begin to breed?

In the first place they probably consider the price at which hogs are selling at the time. If the price is high, they may be inclined to breed more sows than if it is low. It does not follow necessarily, however, that they will breed more sows just because of a high price of hogs, as a price is only high or low by comparison with some other price. That is to say, a high price is only relative; for the hog producer the price of hogs is either high or low as it relates to the price of corn, to the price of cattle, or to the price of some other product. So instead of considering the price of hogs alone, the farmer probably gives more consideration to the relationship between the price of hogs and the prices of other products.

Since corn is the chief feed used in the production of hogs, it would be reasonable to expect that the price of corn, particularly as it is related to the price of hogs, also would have considerable bearing on the number of sows the farmer would be inclined to breed for the next year's market. If the price of hogs is high in relation to the price of corn, then feeding the corn to hogs would appear more profitable than selling it as grain, and the farmer likely would try to breed more sows to take advantage of the favorable situation. If the other way around, then he would be inclined to go less heavily into hogs. So this relation between the price of corn and the price of hogs, or the "corn-hog ratio," we shall consider to be one of the first factors which influences the farmer's inclination to breed hogs.

When we speak of the corn-hog ratio, we mean the total number of bushels of corn required to equal in value 100 pounds of hogs. This ratio varies from time to time because the prices of both corn and hogs vary. Obviously when corn is high in price and hogs are low, not so many bushels of corn will be required to equal in value 100 pounds of hogs as when corn is low and hogs are high. Thus in July, 1924, only

6.7 bushels of corn were required to equal in value 100 pounds of hogs, while in February, 1922, 16.5 bushels were required. During the last twenty-five years, about 11.4 bushels of corn, on an average, have been required to equal in value 100 pounds of live hogs in the Chicago market.

If we take 11.4 bushels of corn as the normal ratio and multiply it by the price of corn month by month over a period of years, and com-

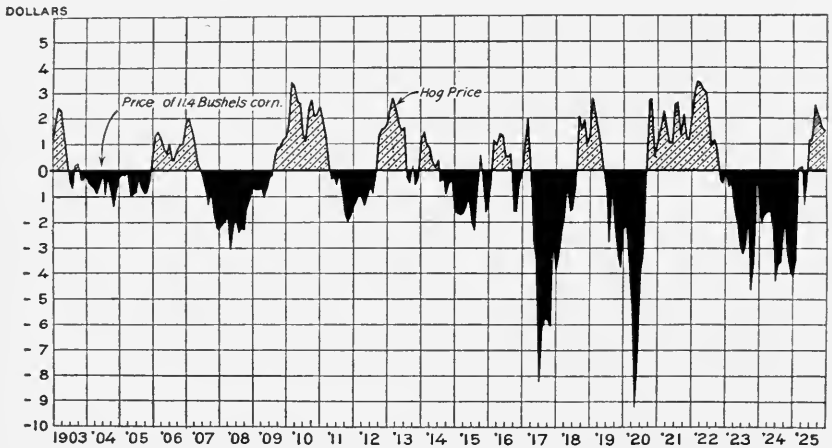


FIG. 7.—THE CORN-HOG RATIO FROM 1903 TO 1925

The shaded areas above the heavy horizontal line show the times when 100 pounds of heavy hogs were worth more than 11.4 bushels of corn. The black areas below the line show when the reverse was true when 100 pounds of heavy hogs were worth less than 11.4 bushels of corn.

pare the resulting products with the corresponding monthly prices of hogs, a clear picture will be obtained of what has been the relationship between them for a period of years.

Fig. 7 has been constructed in this way. The shaded areas above and below the heavy horizontal line show the times in which the value of 100 pounds of hogs has been higher or lower than the value of 11.4 bushels of corn.

Now if the corn-hog ratio has any effect upon the supply of hogs coming to market, it must come about in one of three ways: (1) it must cause farmers to breed either more or fewer sows; (2) it must cause them to send hogs to market at heavier or lighter weights; or (3) it must cause them to sell bred sows before they farrow. This being true it would be reasonable to suppose that such effect as the ratio did have would be

exerted around the time of breeding or during the time the hogs are being fed out and marketed. Since in this connection we are attempting to measure the factors influencing the *number* of hogs coming to market rather than the total weight of live hogs received, the influence which the ratio may exert upon the weight of hogs marketed may be disregarded here.<sup>1</sup>

In the area which sends hogs to the Chicago market, there is a fairly settled policy among farmers with regard to the time at which they breed their sows and have their pigs farrowed. Most of the "spring pig crop" with which we are primarily concerned here is farrowed between late winter and early summer, the majority being farrowed during the months of April and May. Some farmers breed their sows early in November in order to have the pigs farrowed in late February or March, but the rank and file usually breed in December and January.

Since breeding takes place usually from November to February, the ratio of corn to hog prices around that time would be expected to have a greater influence upon breeding than at other times when no breeding is done. The corn-hog ratio in December, therefore, was taken as representative of the relationship between *corn and hog prices at time of breeding*.

The average corn-hog ratio from January to March was used to take care of the effect which the ratio might have upon the *marketing of bred sows*. That is to say, the corn-hog ratio at breeding time might be such as to induce farmers to do some breeding, yet it might change subsequently and cause them to sell the bred sows. For much the same reason the average relationship between corn and hog prices obtaining over a six-months period preceding breeding, that is, from June to November, was used. Presumably if hog production has been profitable for a considerable time, some farmers will be induced to go into the enterprise more heavily because of that fact. Such effect as this has upon stimulating production is separate and in addition to the influence which the ratio has at the time of breeding.

The influence of corn-hog ratios taken at other times upon receipts proved of little or no significance, except in the case of the influence of the corn-hog ratios in May and June upon breeding for fall litters.

In this analysis the reader should bear in mind that the relationship between these various corn-hog ratios and receipts is not measured

---

<sup>1</sup>This, however, is a very important factor and must be given full weight when attempting to measure the influence of the supply of hogs upon price, total weight in that connection being more important than total numbers. In the analysis of the factors determining the price of hogs this factor of weight was given due consideration, and if we may for the time being disregard it, we can consider independently the influence which the corn-hog ratio around time of breeding has on the number of hogs bred.

concurrently. That is, it is not the relationship between the December corn-hog ratio, for example, and receipts of hogs at Chicago in December which is being measured; it is rather the relationship between the December corn-hog ratio and receipts of hogs at Chicago starting the next September and running thru the following April. In other words, there is what is termed a "time lag" between the ratio and receipts. Thus the December corn-hog ratio in 1925 is related to the receipts of hogs at Chicago, not in December, 1925, but to receipts starting in September, 1926, and running thru April, 1927, giving a "time lag" of 9 to 15 months between the ratio and receipts. Similarly the average corn-hog ratio from June to November is related to receipts of hogs at Chicago 12 to 18 months later and, so on for other ratios.

### Effect of December Corn-Hog Ratio

That there is a very close relationship between the corn-hog ratio in December and the receipts of hogs at Chicago starting the next September and running thru the following April, is shown by Table 1. When the price of hogs is high in comparison with the price of corn in December, farmers go into hog production more heavily. As the price of hogs becomes increasingly favorable, farmers tend to increase their production, but the increase takes place in a diminishing ratio; that is to say, a 10-percent increase in the corn-hog ratio above normal (11.4 bushels of corn) does not cause a 10-percent increase in the production of hogs above normal, but results in an increase considerably less than this.

The same facts shown in Table 1 are shown graphically in Fig. 8. The corn-hog ratio is measured on the vertical scale and receipts at

TABLE 1.—NET EFFECT OF THE DECEMBER CORN-HOG RATIO UPON RECEIPTS OF HOGS AT CHICAGO NINE TO FIFTEEN MONTHS LATER<sup>1</sup>

| When the December corn-hog ratio was— | The receipts of hogs at Chicago 9 to 15 months later were— |
|---------------------------------------|--|
| 25% below normal.....                 | 15.12% below receipts of previous year                     |
| 20% " ".....                          | 12.20% " " " " " "   |
| 15% " ".....                          | 9.51% " " " " " "  |
| 10% " ".....                          | 6.44% " " " " " "  |
| 5% " ".....                           | 3.18% " " " " " "  |
| Normal (11.4 bu.).....                | No change, or equalled receipts of previous year           |
| 5% above normal.....                  | 2.68% above receipts the previous year                     |
| 10% " ".....                          | 4.88% " " " " " "  |
| 15% " ".....                          | 6.59% " " " " " "  |
| 20% " ".....                          | 7.80% " " " " " "  |
| 25% " ".....                          | 9.02% " " " " " "  |
| 30% " ".....                          | 9.26% " " " " " "  |
| 35% " ".....                          | 9.51% " " " " " "  |

<sup>1</sup>The influence of other factors upon receipts being taken account of and allowed for, the table shows the amount of change in receipts which was due to given changes in the December corn-hog ratio alone.



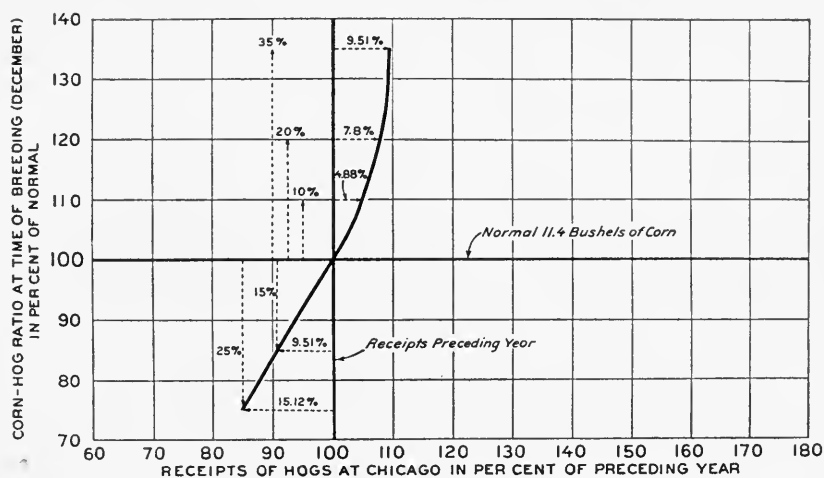


FIG. 8.—NET EFFECT OF DECEMBER CORN-HOG RATIO UPON RECEIPTS AT CHICAGO NINE TO FIFTEEN MONTHS LATER

The heavy horizontal line represents the normal corn-hog ratio; that is, the ratio when 11.4 bushels of corn equal in value 100 pounds of heavy hogs. The heavy vertical line represents the receipts of the previous year, these being taken as "normal." The arrows pointing vertically indicate the extent to which the corn-hog ratio varied above or below normal at December breeding time, and the arrows pointing to the right or the left represent the extent to which receipts 9 to 15 months later were affected. Thus when the corn-hog ratio was 10 percent above normal, the receipts of hogs at Chicago 9 to 15 months later were 4.88 percent above what they were the preceding year, and so on for other ratios. These facts are also presented in Table 1.

Chicago on the horizontal scale, both scales being on a percentage basis. For the corn-hog ratio 11.4 bushels of corn have been taken as normal or 100, and for receipts those of the preceding year are considered normal or 100. These "normal" points are represented by the heavy black lines which intersect near the center of the chart. Changes either in the corn-hog ratio or in receipts are then measured from these lines. Thus when the chart shows an increase of 20 percent in the corn-hog ratio above normal, or a change from 100 to 120 on the vertical scale, an increase of 7.8 percent is shown in receipts measured on the horizontal scale. Similarly the influence which any other change in the corn-hog ratio has on receipts, may be ascertained from the chart.

The December corn-hog ratio, it will be noted, has the greatest influence on receipts when it is between 25 percent below normal and 15 percent above normal. When the corn-hog ratio is very high, a given percentage change from normal does not have so great an influence. This is indicated by the tendency of the curve to turn up sharply in the upper range and to be more nearly vertical than horizontal.

This slowing up in production (receipts) as the corn-hog ratio becomes progressively higher probably is to be accounted for by the fact that some farmers are already beginning to curtail production thru fear of overdoing the thing, and also by the fact that when production gets higher and higher it becomes increasingly difficult to produce more hogs owing to lack of equipment, scarcity of feed, and also to financial limitations.

### Effect of June-November Corn-Hog Ratio

The relation between the June-November corn-hog ratio and receipts of hogs at Chicago 12 to 18 months later is shown in Table 2 and Fig. 9.

TABLE 2.—NET EFFECT WHICH THE AVERAGE CORN-HOG RATIO FOR SIX MONTHS PRECEDING BREEDING HAS UPON RECEIPTS OF HOGS AT CHICAGO TWELVE TO EIGHTEEN MONTHS LATER<sup>1</sup>

| When the average corn-hog ratio for 6 months preceding breeding (av. June-Nov.) was— | The receipts of hogs at Chicago 12 to 18 months later were— |
|--|---|
| 25% below normal.....  | 24.51% below receipts of preceding year                     |
| 20% " " .....  | 19.12% " " " " "  |
| 15% " " .....  | 13.73% " " " " "  |
| 10% " " .....  | 8.83% " " " " "   |
| 5% " " .....   | 3.68% " " " " "   |
| Normal (11.4 bu.).....   | No change, or equalled receipts of previous year            |
| 5% above normal.....   | 3.19% above receipts of preceding year                      |
| 10% " " .....  | 5.63% " " " " "   |
| 15% " " .....  | 8.09% " " " " "   |
| 20% " " .....  | 9.80% " " " " "   |
| 25% " " .....  | 11.03% " " " " "  |
| 30% " " .....  | 12.25% " " " " "  |
| 35% " " .....  | 12.74% " " " " "  |

<sup>1</sup>The influence of other factors upon receipts being taken account of and allowed for, the table shows the amount of change in receipts which was due to given changes in the average corn-hog ratio during the six months preceding breeding.

It will be noted that the curve in Fig. 9 has a wider swing than the curve in Fig. 8, tho it has the same general shape. This means that when there is a given percentage change in this corn-hog ratio from normal ("normal" being taken to mean when 11.4 bushels of corn are equivalent in price to 100 pounds of heavy hogs), there is a much larger percentage change in receipts than when the December corn-hog ratio changes. In fact, when the June-November ratio increases 20 percent above normal, there is a 9.8 percent increase in receipts, while when the December ratio increases similarly there is only a 7.8-percent increase in receipts.

Another fact of interest in these two charts is that when the curves go below the line of normal ratio they turn more sharply to the left than they do to the right when above the normal ratio, indicating that when the ratio is low, an increase in it results in a much larger percentage increase in receipts than when the ratio is high. For example, in Fig. 9 an increase of 10 percent in the ratio when it is low results in an in-

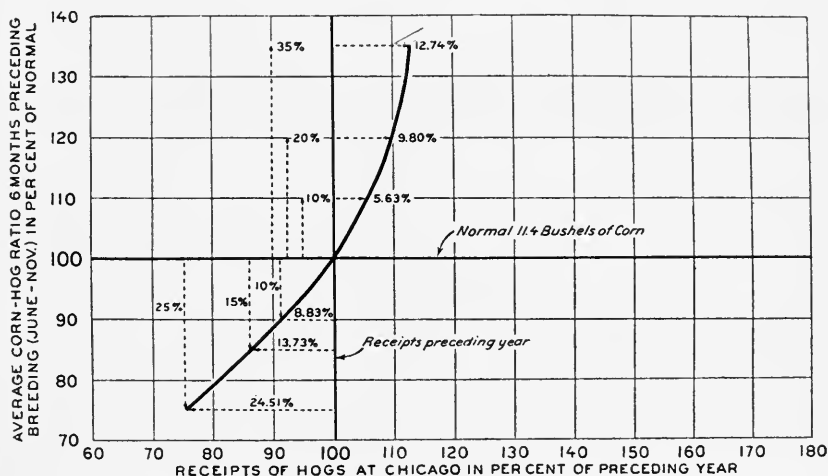


FIG. 9.—NET EFFECT OF AVERAGE CORN-HOG RATIO FOR SIX MONTHS PRECEDING BREEDING UPON RECEIPTS OF HOGS AT CHICAGO TWELVE TO EIGHTEEN MONTHS LATER

This chart is read in the same way as Fig. 8. When the corn-hog ratio was 10 percent above normal the receipts 12 to 18 months later were 5.63 percent above normal. A change to 35 percent above normal resulted in an increase of 12.74 percent in receipts; a drop to 25 percent below normal resulted in a 24.51 percent decrease in receipts. See Table 2 for further ratio changes and their effects.

crease of 8.83 percent in receipts. When the ratio is very high, however, an increase of 10 percent results in an increase in receipts of only 5.63 percent. Which means that when the corn-hog ratio is low, any upward change making the ratio more favorable to hogs is met by a very decided response on the part of farmers in increasing their production of hogs; and that when the ratio is already high, any further upward change results in relatively less response in production. In the one case it may be said that the response is very "elastic," in the other that it is relatively "inelastic."

#### Effect of January-March Corn-Hog Ratio

A third corn-hog ratio which was found to be closely related to receipts of hogs is that covering the period from January to March follow-

ing the usual breeding date around December 1 (Table 3 and Fig. 10). The curve in Fig. 10, it will be noted, swings to the opposite sides of the normal lines from the curves shown in Figs. 8 and 9, indicating that when the corn-hog ratio rises during this period following breeding, receipts 6 to 12 months later decrease; and when the ratio drops, receipts 6 to 12 months later increase. After sows are bred in December it is not an uncommon practice for farmers to ship them to market before they farrow in the spring. When there is a change in the relationship between corn and hog prices after the sows are bred, making the

TABLE 3.—NET EFFECT WHICH THE AVERAGE CORN-HOG RATIO FOR THREE MONTHS FOLLOWING BREEDING HAS UPON RECEIPTS OF HOGS AT CHICAGO SIX TO TWELVE MONTHS LATER<sup>1</sup>

| When the average corn-hog ratio for 3 months following breeding (av. Jan.-March) was— | The receipts of hogs at Chicago 6 to 12 months later were— |
|---|--|
| 25% below normal.....   | 10.94% above receipts of preceding year                    |
| 20% " ".....  | 7.46% " " " " " "  |
| 15% " ".....  | 4.23% " " " " " "  |
| 10% " ".....  | 1.74% " " " " " "  |
| 5% " ".....   | .49% " " " " " "   |
| Normal (11.4 bu.).....  | No change, or equalled receipts of preceding year          |
| 5% above normal.....  | .50% below receipts of preceding year                      |
| 10% " ".....  | .50% " " " " " "   |
| 15% " ".....  | .75% " " " " " "   |
| 20% " ".....  | 1.00% " " " " " "  |
| 25% " ".....  | 1.25% " " " " " "  |
| 30% " ".....  | 1.50% " " " " " "  |
| 35% " ".....  | 1.50% " " " " " "  |

<sup>1</sup>The influence of other factors upon receipts being taken account of and allowed for, the table shows the amount of change in receipts which was due to given changes in the average corn-hog ratio for the three months following breeding.

ratio more favorable to corn and less favorable to hogs, then farmers are more likely to sell the bred sows and have fewer hogs to send to market later. On the other hand, an increase in the corn-hog ratio may cause farmers to hold on to their sows longer, or even to keep back additional sows for late breeding, and this fact is reflected in higher receipts.<sup>1</sup>

<sup>1</sup>In this analysis the effect of this ratio upon receipts was directly opposed to this and hence contrary to theoretical expectations.

In Tables 3, 5, and 6 in the Statistical Appendix it will be noted that there is very high intercorrelation between this factor and the other factors used. This being true, the direct determination of this factor upon receipts, tho in itself positive, becomes negative in the presence of the other factors whose joint determination overshadows it. (See Statistical Appendix, page 557.)

At its greatest, however, the effect of the corn-hog ratio for the three months following December, when the ratio is above normal, is practically negligible. About the only influence which this ratio has upon re-

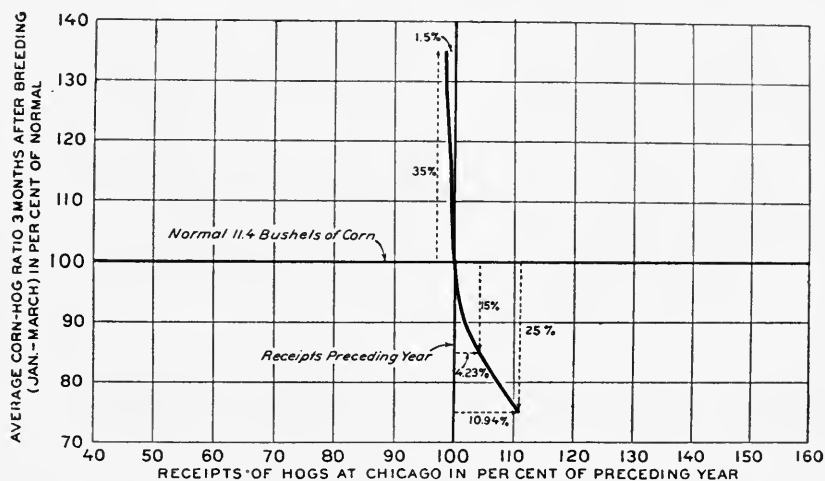


FIG. 10.—NET EFFECT OF CORN-HOG RATIO FOR THREE MONTHS AFTER BREEDING UPON RECEIPTS AT CHICAGO SIX TO TWELVE MONTHS LATER

When the average January to March ratio was 35 percent above normal, receipts of hogs at Chicago changed only 1.5 percent from normal. When the ratio is 10 percent below normal, however, receipts increase. This increase amounts to almost 11 percent when the ratio is 25 percent below normal.

ceipts occurs when hog prices are low in comparison to corn prices; then it is appreciable.

### Effect of All Three Corn-Hog Ratios

Over an eighteen-year pre-war period, from 1898 to 1916, it was possible to account for a little more than 70 percent of the variation in receipts of hogs at Chicago by means of these three corn-hog ratios "lagged" as indicated.<sup>1</sup> This is brought out in Table 4 and Fig. 11.

### Hog-Steer Ratio a Minor Factor

The Illinois farmer, particularly in the livestock section west of the Illinois river, has many opportunities of production open to him. He may feed corn to hogs, feed it to beef cattle (or to sheep), or sell the corn direct as grain. The way in which he will dispose of it will be determined by what he considers is the most profitable of the different enterprises.

<sup>1</sup>A detailed discussion of the method used and the theoretical background for the conclusions drawn here will be found in the Statistical Appendix.

TABLE 4.—NET EFFECT WHICH THE COMBINED CORN-HOG RATIOS HAVE UPON RECEIPTS OF HOGS AT CHICAGO SIX TO EIGHTEEN MONTHS LATER<sup>1</sup>

| When the corn-hog ratio was— | The receipts of hogs at Chicago 6 to 18 months later were— |
|------------------------------|--|
| 25% below normal.....        | 9.67% below receipts of preceding year                     |
| 20% " ".....                 | 8.02% " " " " " "  |
| 15% " ".....                 | 6.40% " " " " " "  |
| 10% " ".....                 | 4.48% " " " " " "  |
| 5% " ".....                  | 2.12% " " " " " "  |
| Normal (11.4 bu.).....       | No change, or equalled receipts of preceding year          |
| 5% above normal.....         | 1.81% above receipts of preceding year                     |
| 10% " ".....                 | 3.39% " " " " " "  |
| 15% " ".....                 | 4.67% " " " " " "  |
| 20% " ".....                 | 5.55% " " " " " "  |
| 25% " ".....                 | 6.34% " " " " " "  |
| 30% " ".....                 | 6.73% " " " " " "  |
| 35% " ".....                 | 6.98% " " " " " "  |

<sup>1</sup>The three corn-hog ratios, (1) in December at time of breeding, (2) the average for the six months (June-November) preceding breeding, and (3) the average for the three months (January-March) following breeding, have been combined into one ratio according to the net effect of each upon receipts.

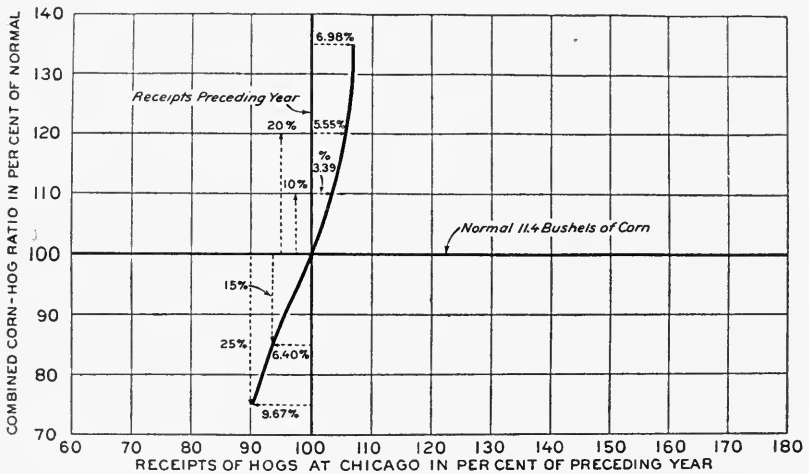


FIG. 11.—NET EFFECT OF ALL THREE CORN-HOG RATIOS UPON RECEIPTS OF HOGS AT CHICAGO SIX TO EIGHTEEN MONTHS LATER

The three ratios, (1) in December at time of breeding, (2) for six months preceding breeding, and (3) for three months after breeding, account for more than 70 percent of the variation in receipts at the Chicago market. When the combined ratios stand at a height of 35 percent above normal, receipts 6 to 18 months later increase about 7 percent; when at a level of 25 percent below normal, receipts for the same period decline almost 10 percent (9.67 percent).

This does not mean necessarily that he will feed all of his corn to hogs, or all to beef cattle, nor yet sell it all as grain. He may utilize it in

all three ways, or he may feed part to hogs and plan on selling some of it, or he may feed both hogs and cattle or even buy additional corn. Just what he will do in any particular year will be determined by the outlook for profitable returns in each of the alternatives open to him. If there is a good prospect for the price of hogs to be high, and the price of cattle and corn to be low, he will probably go into hog production more heavily and reduce his cattle-feeding operations somewhat. Or, on the other hand, if the price of cattle promises to be relatively higher than the price of hogs, he may go into cattle a little more strongly and hogs somewhat less. Whichever course he pursues will be reflected in the supply of hogs as well as of cattle.

So the relation which hog prices bear to cattle prices preceding and at the time the farmer begins to breed his sows is a factor which may influence his breeding operations. In this study this factor was found to be of relatively small importance in explaining fluctuations in hog receipts, tho it is of sufficient importance to merit consideration.

## FACTORS THAT LIMIT A FARMER'S ABILITY TO PRODUCE HOGS

### Lack of Breeding Stock, Capital, Equipment

Ordinarily the Illinois farmer has little difficulty in increasing or decreasing his production of hogs whenever and however he desires. There are two factors, however, which possibly may limit his actions. They are: (1) lack of breeding stock at time of breeding, and (2) lack of capital and equipment and facilities for handling hogs. Neither of these factors in general is of very great significance, yet at certain times either one *may* be of enough importance to cause some limitation in production.

It usually is very easy to get in and out of hog production; comparatively little capital or equipment is necessary, particularly for spring and summer pigs, and usually breeding stock (sows) can be obtained at low cost. When a farmer desires to increase his production, he will simply keep out some of his best gilts and breed them. Of course if going into hog production means buying both breeding stock and feed, then lack of capital may be a very limiting factor, but this situation rarely obtains on the corn-belt farm.

There may come times, however, when the lack of breeding stock may prevent farmers from going into hog production as heavily as they otherwise would. Such a situation is likely to obtain immediately after a serious epidemic of hog cholera. While vaccination keeps these cholera epidemics in check fairly well, occasionally they get out of

control and cause big losses. Oftentimes whole herds are wiped out almost completely. It is under circumstances such as these that there may develop a serious shortage in breeding stock which is very likely to result in lower receipts the following year.

There is still another way in which a shortage in breeding stock may limit the extent to which certain farmers can go into hog production. It is felt mainly by those farmers who ordinarily sell grain instead of feeding it. In years in which corn prices are low, these farmers being desirous of realizing as much from their corn crop as possible likely will attempt to feed some of it to hogs. Since hog production is not a common practice with them, they will have to "buy in." That is, they either will have to buy breeding stock or buy feeder hogs. It usually happens in a situation like this that farmers everywhere feel the desire to go into hogs somewhat more heavily, and the demand for breeding stock increases. Of course the hog producer will supply his own needs first, and farmers wishing to buy breeding stock will have to be satisfied with what remains. It is not unusual in these circumstances for a shortage in breeding stock to develop. If a shortage does materialize, it means that many farmers will not go so heavily into hog production as they otherwise would have done; hence the supply of hogs the following year will not be so large.

#### **FACTORS THAT WORK AGAINST A FARMER'S EFFORTS IN HOG PRODUCTION**

##### **Weather Conditions at Farrowing Time**

In addition to the groups of factors that have to do with a farmer's inclination and ability to produce hogs, there is a third group which tends to work against his efforts. These are unfavorable weather conditions at farrowing time and the presence of disease and parasites. Farmers may be desirous of going into hog production very heavily and may breed a large number of sows for that purpose, yet their efforts maybe materially thwarted by heavy pig losses at farrowing time resulting from unfavorable climatic conditions. Of course farmers can control these conditions in a measure by providing comfortable quarters and by giving excellent care and attention to sows and pigs, yet some loss will result in spite of the best of care. While the better farmers will keep their pig losses down, the majority of hogs are produced under conditions in which the best methods of production and sanitation are not practiced; hence the pig loss likely will be much greater in unfavorable weather.

In order to measure the influence of climatic conditions at farrowing time upon pig loss, and consequently upon subsequent receipts of



hogs at Chicago, an index of climate or some other factor capable of statistical measurement had to be constructed. What should such an index include or, in other words, what are the climatic conditions at farrowing time which are likely to result in heavy pig losses?<sup>1</sup> Three

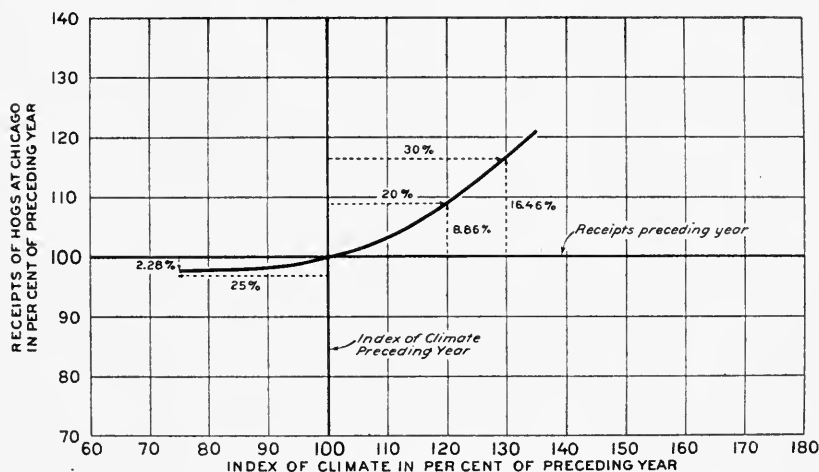


FIG. 12.—EFFECT OF CLIMATIC CONDITIONS AT FARROWING TIME UPON RECEIPTS OF HOGS AT CHICAGO SIX TO TWELVE MONTHS LATER

Normal climate is represented by the heavy vertical line in the chart and normal receipts of preceding year by the heavy horizontal line, while changes in receipts resulting from changes in climate are shown by the curve. Thus when climatic conditions are below normal, receipts fall off, as shown by the way the curve drops down; and when above normal, receipts increase, as indicated by the rapid rise of the curve. A 20-percent rise in climatic conditions above normal brought 8.86 percent more hogs to market 6 to 12 months later. A rise of 30 percent in climatic conditions above normal brought 16.46 percent more hogs to market. (See also Table 4).

factors were found to be of most importance: departure of temperature from normal, amount of precipitation (number of rainy days), and number of sudden changes in temperature. That is to say, years when a large amount of rain accompanied by temperatures below normal and a large number of sudden changes in temperature occur, pig losses likely will be heavier than they will be when these conditions do not obtain. (See Fig. 12.)

### Disease

This factor needs but little discussion. Its influence is self-evident. The more disease there is the greater will be the death loss, and the greater the death loss the greater the influence upon receipts. This factor can be controlled to a considerable degree by the farmer if he will take

<sup>1</sup>See Statistical Appendix for discussion of this index.

proper precautions and follow sensible and sanitary practices for controlling cholera, worms, and other diseases and parasites.

### The Upward Trend in Production

During the eighteen years covered by this study there was an upward trend in the production of hogs. Receipts at Chicago from September to April of each year during this period increased at the rate of a little more than one-half of 1 percent (.65 percent) per year. This increase over a long period of time is separate and distinct from increases due to the other factors we have discussed and must be so treated. It is an especially important factor to consider when attempting to explain differences in receipts over a period of years or in attempting to estimate

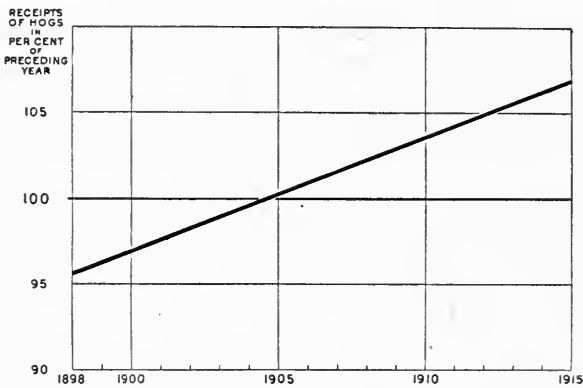


FIG. 13.—INCREASES IN RECEIPTS AT CHICAGO FROM 1898 TO 1915 DUE TO THE UPWARD TREND IN PRODUCTION

This upward tendency in production is largely due to increases in population. For the period shown it amounted to a little more than  $\frac{1}{2}$  of 1 percent (.65 percent) a year.

what receipts will be in the future. Unless this upward tendency or growth in receipts due to the increase in population and other basic factors is taken into consideration, the estimate of receipts made from current factors will be too low. Fig. 13 shows the increase in receipts at Chicago which has resulted from this upward trend of production alone, the influence of other factors upon receipts having been taken into account and eliminated.

### Relative Importance of Various Supply Factors

As has already been pointed out, a little more than 70 percent of the variation in receipts of hogs at Chicago for the period from 1897 to

1914 can be accounted for by the effects of three corn-hog ratios. Farmers apparently are influenced in their breeding operations more by the relation between corn and hog prices than by any other one thing. The relation in December at the time of breeding for spring litters and during the six months preceding breeding appear to have the greatest influence upon breeding operations. Climatic conditions at farrowing time are the next most important factor influencing receipts, this factor accounting for about 18 percent of the variation shown in the present analysis.

The relation between hog and steer prices, size of the corn crop or percentage of non-merchantable corn, number of sows available for breeding stock, etc., are of minor importance so far as this analysis indicated. While there was found to be some relationship between each of these factors and receipts, it was of negligible significance as compared with the important influence of the corn-hog ratios and climatic conditions at farrowing time.

That the factors which we have been discussing are the fundamental determinants of supply can hardly be doubted. The high correlation<sup>1</sup> between them and receipts (which are the measure of supply) in the Chicago market over a period of years indicates that this is true. Since the major portion of the hogs (90 percent or more) which come to Chicago are produced in Iowa, Illinois, Wisconsin, and Minnesota, these factors may be considered the chief determinants of supply over that whole area.

### PART III

#### RESPONSE OF HOG PRODUCERS IN DIFFERENT SECTIONS OF ILLINOIS TO CORN-HOG RATIO

It does not follow necessarily from the foregoing that all farmers respond in the same way to given changes in the various factors affecting hog production. The conditions under which production takes place vary from area to area. Farmers vary widely also in resources and opportunities. For these and other reasons they do not increase and decrease their production of hogs in the same way or to the same extent from year to year.

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<sup>1</sup>A coefficient of multiple correlation of .983 was obtained. Such a coefficient shows the degree of relationship between a particular resultant and certain "causal" factors related to it (a coefficient of 1.0 means perfect correlation, or complete determination). See Statistical Appendix for detailed discussion of method of computation.

How farmers in different sections of Illinois have responded to changes in the corn-hog ratio is indicated in Table 5. The influence of other factors upon production having been taken into account and al-

TABLE 5.—NET EFFECT OF VARIOUS CORN-HOG RATIOS<sup>1</sup> UPON PRODUCTION OF HOGS IN DIFFERENT TYPE-OF-FARMING AREAS IN ILLINOIS

| When corn-hog ratio is—   |  | Hog production, in percentage of previous year, has been— |  |   |  |
|---------------------------|--|---|--|---|--|
| In actual bushels of corn | In percentage of normal ratio (11.4 bu.) | In the <i>grain</i> section, east central Illinois        | In the <i>live-stock</i> section, western Illinois | In the <i>wheat</i> section, south western Illinois | In the <i>dairy</i> section, northern Illinois |
| <i>bu.</i>                | <i>perct.</i>                            | <i>perct.</i>   | <i>perct.</i>                                      | <i>perct.</i>                                       | <i>perct.</i>                                  |
| 7.98                      | 70                                       | 88.78   | 97.02  | 96.90   | 95.19  |
| 8.55                      | 75                                       | 90.33   | 97.57  | 97.28   | 95.88  |
| 9.12                      | 80                                       | 92.21   | 98.07  | 97.72   | 96.62  |
| 9.69                      | 85                                       | 93.92   | 98.29  | 98.21   | 97.41  |
| 10.26                     | 90                                       | 95.58   | 98.56  | 98.64   | 98.15  |
| 10.83                     | 95                                       | 97.62   | 99.17  | 99.34   | 98.99  |
| 11.40                     | 100                                      | 100.00  | 100.00   | 100.00  | 100.00   |
| 11.97                     | 105                                      | 102.26  | 100.88   | 101.09  | 101.54   |
| 12.54                     | 110                                      | 104.53  | 102.04   | 102.72  | 102.85   |
| 13.11                     | 115                                      | 107.18  | 103.76   | 104.62  | 104.28   |
| 13.68                     | 120                                      | 109.94  | 105.47   | 106.63  | 105.76   |
| 14.25                     | 125                                      | 112.43  | 108.07   | 108.86  | 106.40   |
| 14.82                     | 130                                      | 115.47  | 110.61   | 111.30  | 107.09   |
| 15.39                     | 135                                      | 118.18  | 113.20   | 114.40  | 108.15   |
| 15.96                     | 140                                      | 121.27  | 115.52   | 118.21  | 109.20   |

<sup>1</sup>The corn-hog ratios "lagged" at different periods have been combined into one ratio according to the net effect of each upon the production of hogs as indicated by receipts at the Chicago market 6 to 18 months later.

The data from which this table was made were obtained by running numerous multiple correlation analyses between the number of hogs on farms from year to year in each type-of-farming area and the corn-hog ratio (with various lags), the hog-steer ratio, size of corn crop, trend, etc. (see Statistical Appendix for detailed discussion). The corn-hog ratio (with various lags) proved to be the most important factor influencing production and has been used here for that reason.

lowed for, the table indicates the amount of change in production which has accompanied a given change in the corn-hog ratio.

#### GRAIN SECTION, EAST-CENTRAL ILLINOIS

In east-central Illinois, it will be noted, a given change in the corn-hog ratio has resulted in a larger percentage change in production than in other sections of the state; that is to say, farmers in east-central Illinois have varied their production of hogs much more widely from year to year than have farmers in other sections of the state. In this section

grain production is the predominant type of farming. Corn and oats are the leading cereals. While there are a large number of farmers who grow and fatten hogs for the market, the majority of them ordinarily sell the corn and oats as grain instead of feeding it. Yet when the price of corn is very low in comparison with the price of hogs, many farmers

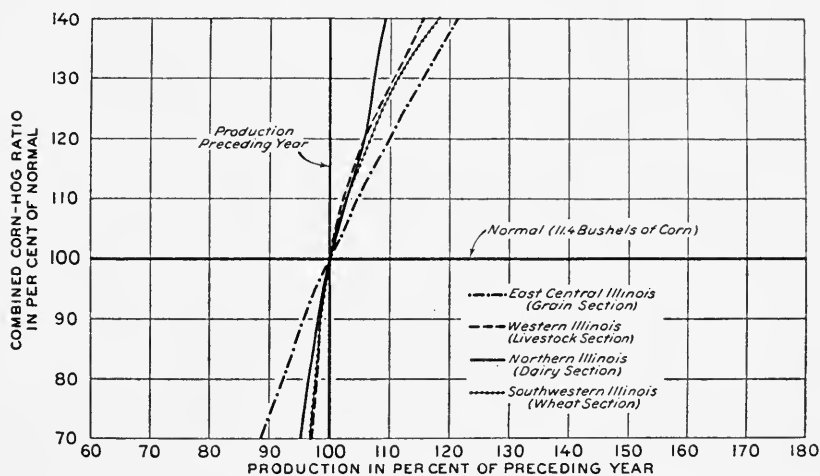


FIG. 14.—NET EFFECT OF THREE CORN-HOG RATIOS COMBINED UPON PRODUCTION OF HOGS IN DIFFERENT TYPE-OF-FARMING AREAS IN ILLINOIS

This chart is read in the same way as Figs. 9 to 12 except that there are four curves to be taken into consideration instead of one, the different curves representing different areas of the state. It is in the grain section of east-central Illinois that the greatest proportional change in hog production occurs with a change in the corn-hog ratio. This is indicated by the fact that the curve for this area moves away from the perpendicular line at a greater angle than does the curve for any other section. The less the effect, the closer the curve comes to the perpendicular.

who do not ordinarily raise hogs will go into hog production in an endeavor to realize as much from the corn crop as possible. When the situation changes and the price of corn again becomes high in comparison with the price of hogs, they will cut down their production of hogs very rapidly, go out of the enterprise almost completely, and sell corn instead of feeding it. This is indicated very clearly in the curve in Fig. 14, which ascends and descends much less steeply than the curves showing changes in production in the other areas.

#### LIVESTOCK SECTION, WESTERN ILLINOIS

In western Illinois, in the area west of the Illinois river, corn is again the leading cereal, yet the major portion of it is fed and sold in the

form of meat rather than as grain. When hog prices are high, farmers increase their production of hogs considerably but their percentage increase is not so great as in east-central Illinois. When hog prices are low in comparison with corn prices, they reduce hog production somewhat but do not go out of the enterprise so rapidly as do the farmers in east-central Illinois. This is indicated in Fig. 14 by the curve for western Illinois tending toward the perpendicular in the lower range.

In this section cattle feeding is practiced rather widely, much of the corn crop being utilized in this way. Cattle feeding thus competes with hog production in the utilization of the corn crop. In case the outlook for cattle prices is favorable, farmers are likely to feed more cattle and not so many hogs. Yet even if hog prices become very unfavorable, they will not give up the enterprise completely. In this section it is a common practice to keep a few hogs to run with the cattle in order to utilize waste and undigested grain, and this partially explains why production is less elastic when the corn-hog ratio is low than when it is high, that is, why even tho prices are unfavorable for hogs, these farmers do not stop growing them.

#### WHEAT AND DAIRY SECTIONS

In southwestern Illinois hog production is not commercialized to the same extent as in some of the other sections; that is, farmers are not in hog production so heavily. They keep about the same number of hogs from year to year, yet increase their production somewhat when prices become very favorable. The same is true of hog production in the dairy section around Chicago.

Thus farmers in different sections of the state vary their hog production from year to year according to their own particular situations. They engage in those lines of production which seem to them most profitable or to fit in best with their sectional advantages and limitations, their organization, equipment, and financial circumstances. Of course not all farmers interpret a given situation in the same way. To some farmers the outlook for hog prices may appear very favorable at a particular time, while to other farmers it may not appear favorable at all. One group may be considering the immediate price situation at the time of breeding, while another group is looking to the future, to what the situation will be when the pigs are grown and come to market. These different responses result in wide fluctuations in production and account for the periodic shifting up and down not only of the supply of hogs but of the price also.

## PART IV

### ADJUSTING HOG PRODUCTION TO MARKET DEMAND

The fact that there is a periodic shifting up and down in the supply and price of hogs about every 15 to 18 months indicates that the majority of farmers respond to current market conditions rather than to those that are likely to prevail when their hogs are ready for market.

Not all farmers, however, produce hogs in such a blind and haphazard way. In fact the thinking farmer adjusts his production so as to take advantage of the mistakes of his less alert neighbors. Instead of going into hog production when the immediate situation is favorable, he holds off fearing overproduction and gets in at a more strategic time later when large numbers of farmers are going out of production. Furthermore he takes advantage of the favorable markets in early spring and fall and plans to have his hogs come to market when the majority of other farmers are not selling. In this way he is usually able to make hog production a profitable undertaking. It is to the few successful producers—those who adopt up-to-date methods and practices and make money—to whom we must give attention if we are to find methods and practices which may be of help to the less successful.

#### SUCCESSFUL FARMERS POINT THE WAY

In the remaining pages the discussion will center around the methods and practices of some Illinois producers who have been especially successful in their hog enterprise. An account of the experience of these farmers it is hoped will be of help to other farmers in improving their methods and practices. There probably are many other hog producers in the state who are just as successful as these men, but these farms have been taken for illustration because there is information about them extending back over a continuous ten-year period. They are taken also because they illustrate practices which are especially important in determining the success of the hog enterprise.

In the discussion of these farms, as well as in the subsequent discussion, major emphasis will be placed on the importance of three practices: (1) adjusting production to meet anticipated price changes; (2) marketing, in so far as possible, in months in which the price is highest; (3) taking account of changes in price relationships and selecting from the many alternative lines of production that one or more which gives promise of yielding the greatest net return.

It is recognized that these practices are but a few among a large number of factors which determine success in hog production. In focusing attention on them, such other factors as management of the breeding

herd, care and attention at farrowing time, feeding practices, size of litter, pigs saved per litter, sanitation and disease control, must not be overlooked.

### Methods and Practices on Farm No. 1

The operator of this farm of 140 acres is an example of one who has been very successful with hogs as well as with other farm enterprises. Besides being an efficient producer, he has exercised good judgment in planning his production and in choosing other lines to supplement hog production. He has weighed very carefully the alternatives open to him and has usually selected the one which has proved profitable.

**Production Pointed for High Markets.** This farmer has varied the number of sows bred from year to year rather widely (Table 6). How closely these adjustments have corresponded with changes in the price

TABLE 6.—ANNUAL ADJUSTMENTS IN HOG AND SHEEP PRODUCTION ON FARM NO. 1

| Year | Number of sows bred the previous fall for spring farrow | Number of sheep fed <sup>1</sup> |
|------|---|----------------------------------|
| 1916 | 20  | ...                              |
| 1917 | 22  | ...                              |
| 1918 | 47  | ...                              |
| 1919 | 42  | ...                              |
| 1920 | 25  | ...                              |
| 1921 | 25  | 900                              |
| 1922 | 20  | 927                              |
| 1923 | 55  | None                             |
| 1924 | 85 <sup>2</sup>   | 444                              |
| 1925 | 70 <sup>2</sup>   | 850                              |
| 1926 | 60  | ...                              |

<sup>1</sup>No data available prior to 1921.

<sup>2</sup>In 1924 73 sows farrowed. In 1925 this farmer had trouble in getting the sows to breed; of 70 bred only 34 farrowed.

of hogs is shown in Fig. 15. It will be observed that with the exception of only one or two years over this ten-year period this farmer has changed his production at the strategic time. In years in which the price of hogs was low relatively speaking, as in 1921 and 1923, he has adjusted his production in such a way as to have only a few hogs to sell. In other years, like those of 1919 and 1925, when the price was high, he had increased his production so as to have a large number to sell. This is indicated by the big increase in number of sows bred; which in 1918 was 47 and in 1924, 85. Only 73 sows, however, farrowed in 1924. Yet in



1920, 1921, and 1922, when the price was low, he bred only 24, 25, and 20 sows respectively.

**Pigs Farrowed in Late Spring and Early Summer.** On this farm only one litter of pigs a year is raised by each sow. The sows are usually

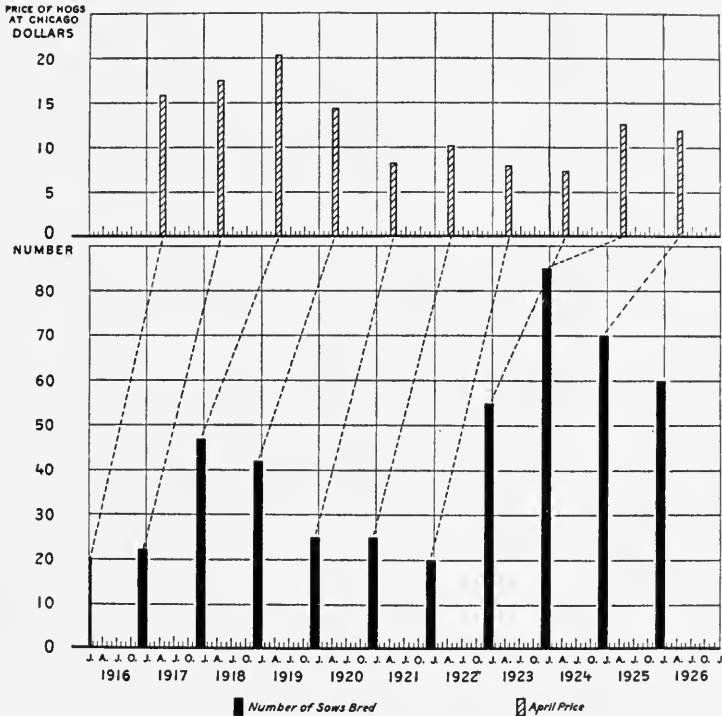


FIG. 15.—HOW ONE ILLINOIS FARMER HAS ADJUSTED HIS PRODUCTION OF HOGS TO MEET ANTICIPATED PRICE CHANGES

The dotted line connecting two bars indicates when the pigs resulting from a breeding were sold. Note that the sows were bred each year between December and February and the pigs sold in April of the second year. This man bred more sows when the outlook was for higher hog prices and fewer when it was for lower prices. The success with which he anticipated prices is evidenced by the fact that he had many hogs to sell when prices were high and few to sell when they were low.

bred so as to farrow in late spring and early summer (May and June). The pigs are brought along gradually on legume pasture until the corn is ready for "hogging," at which time they are turned into the cornfield. They are allowed to remain until the corn is cleaned up. They are then sold in the spring, in March and April. Sometimes the sows are bred to farrow in early spring and the pigs are pushed for the September

market to get ahead of the big rush of receipts in October, November, and December.

Thus this man not only increases and decreases his production from year to year at the strategic time, but also regulates his breeding so as to have his pigs ready for market in those months of the year in which hog prices are usually the highest. This practice makes it necessary to look ahead for a period of a year or more to what conditions will be when the hogs come to market. That this farmer has judged the future with remarkable accuracy is attested by the way he has adjusted his production so as to have many hogs to sell when the price is high and few hogs to sell when the price is low.

**Chooses Profitable Alternative Enterprises.** In a system of farming in which most of the crops are pastured off, as on this farm, the farmer has considerable leeway in what he may do. He may feed hogs and sheep, hogs and cattle, hogs, sheep and cattle, or he may not feed any livestock at all but sell the corn and oats as grain and use the legume pasture mixture for soil improvement. On this farm the usual practice is to make hogs the major livestock enterprise and supplement this by feeding either sheep or cattle. As a usual thing hogs and sheep are the chief classes of livestock handled.

In years in which the outlook for sheep prices is favorable, this man increases the number of sheep fed somewhat and cuts down on the number of hogs produced unless the price outlook for hogs is also very favorable; in which case he increases both hogs and sheep and buys extra corn if necessary to feed them out. This he did in 1925. He fed 850 sheep in 1925 as compared with 444 in 1924 and sold over \$9,000 worth of hogs in 1925. In order to handle the extra livestock, he bought about 1,300 bushels of corn. In 1921 this man had hog cholera on his farm and as a result lost a number of hogs. Nine hundred sheep were fed out to bridge this loss.

On the other hand, when the outlook for sheep prices is not so favorable, he cuts down considerably on sheep and increases hogs if the market outlook is favorable for hogs. Or, if the outlook for cattle is good, he may feed cattle. Thus he is constantly weighing the advantages and disadvantages of the various alternatives or opportunities open to him and is seeking to ascertain which method of utilizing the feed will be most profitable.

In summarizing his practices this farmer said he attempts to get all the information available on the outlook for hog and corn prices, also on the prices of other alternative enterprises in which he might engage, such as cattle and sheep; likewise he attempts to ascertain as accurately

as possible what other farmers are thinking about and are expecting to do, and then he engages in the line or lines of production which give promise of returning the greatest net income. In conclusion he said, "I think it is a very good policy to walk when most other farmers are running and to run when they walk." By which he meant, of course, that he cuts down on the number of hogs produced when other farmers are overdoing the thing, and gets in when there are but few hogs coming to market.

### Farm No. 2 Illustrates Similar Practices

This farm, operated by a young tenant, has been selected because it illustrates four or five practices followed in handling hogs which have proved very profitable.

This farmer, it will be noted, has varied the number of sows bred from year to year rather widely (Table 7). That he has anticipated the changes in the price of hogs and has changed the number of sows bred in time to take advantage of these expected changes in price with a high degree of accuracy is evident from Fig. 16. He has not waited until the price of hogs was low before he reduced the number of sows bred, but has begun to reduce six months to one year before the big slump in price has come. In so doing he has escaped, in a large measure, the big price decline which follows heavy receipts and has avoided being caught with a large number of hogs to sell when the price is low.

Furthermore this farmer regulates his breeding operations in such a way as to have his hogs come to market in those months of the year in which hog prices are usually highest. We have already indicated in the previous discussion that hog prices are usually higher in the spring

TABLE 7.—ANNUAL ADJUSTMENTS IN SOWS BRED ON FARM NO. 2

| Year | Number of sows bred the previous fall |
|------|---------------------------------------|
| 1917 | 12                                    |
| 1918 | 23                                    |
| 1919 | 39 <sup>1</sup>                       |
| 1920 | 36 <sup>2</sup>                       |
| 1921 | 20                                    |
| 1922 | 40                                    |
| 1923 | 25                                    |
| 1924 | 44                                    |
| 1925 | 52 <sup>3</sup>                       |
| 1926 | 40                                    |

<sup>1</sup>27 sows were bred for spring litters and 12 for fall litters.

<sup>2</sup>26 sows were bred for spring litters and 10 for fall litters.

<sup>3</sup>In 1925 52 sows were bred, but only 21 farrowed. This man had the same trouble in getting sows to breed that was experienced on Farm No. 1.

and fall months, particularly in April and September, than at any other time. These are the months in which this farmer plans to sell his hogs.

His usual plan is to breed his sows to farrow in March and May. The March pigs are pushed and sold at six months of age in the Septem-

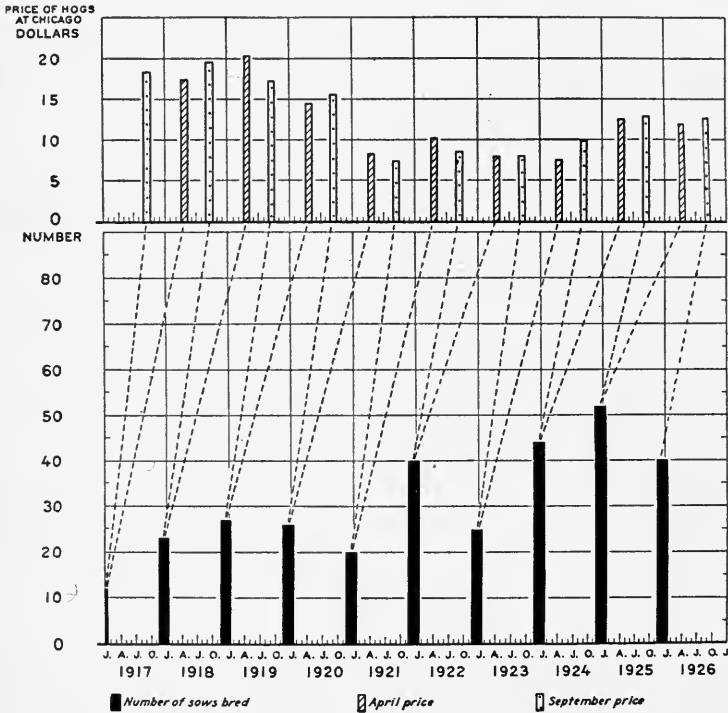


FIG. 16.—ANOTHER ILLINOIS FARMER BASES HOG PRODUCTION ON PRICE OUTLOOK

As in Fig. 15 the dotted lines connecting the bars indicate when the hogs resulting from the bred sows were sold. It will be noted that this farmer sells some hogs in September and others in April. His breeding dates consequently run from early November to January 15 or later. How closely he has changed his production to meet anticipated changes in price may be seen from the chart.

ber market, and the May pigs are held longer and sold at ten or eleven months of age the following March or April. The May pigs are farrowed and grown on legume pasture. This in addition to being economical keeps the pigs healthy and free from worms. They are turned into the cornfields in the fall when the corn is ready for "hogging," and are finished in the feed lot.

In years in which the price of hogs is comparatively high at time of breeding but is expected to slump considerably in the following fall, this farmer plans to have his sows farrow very early in March. The pigs are pushed as rapidly as possible and got on to the market the latter part of August or early September. Thus he tries to get ahead of the big rush of spring litters that starts in October and continues thru the winter months.

In years like 1924, when corn is expected to be high in price in the summer months, he has more of his sows farrow in late spring and early summer, and then carries the pigs along gradually and sells the following spring. In this way he avoids the heavy receipts in the fall. In such a situation most farmers feed to lighter weights, and they also unload breeding stock to avoid feeding the high-priced corn. This usually results in the peak of receipts coming earlier in the season, which causes the price to break earlier than usual. That is to say, the usual seasonal price differential is smoothed out considerably.

By way of summary then, we may say that the practices which make hog production profitable on this farm are: (1) efficient production; (2) adjusting production from year to year according to the outlook for hog prices; (3) selling hogs in those months of the year in which hog prices are usually highest; (4) varying the weight to which hogs are fed according to whether corn prices are high or low in relation to hog prices.

### Farm No. 3 Another Example of Successful Practices

This is an example of another farmer who has been very successful with hogs. This man, it will be noted, has not increased or decreased the number of sows bred from year to year quite so widely as have the other two farmers we have been discussing, yet he has kept by no means a constant number from year to year (Table 8). In fact, he has varied from 12 sows bred in 1916, to 36 in 1922, and to 35 in 1924.

In explaining his practices this man says he does not plan to shift very widely from year to year but expects to increase, and does increase, the number of sows bred in years in which the price outlook for hogs is favorable. Also he sells at varying weights, feeding out to heavier weights when the price of corn is low in comparison with the price of hogs and to lighter weights when the price of corn is high and the price of hogs low. Fig. 17 shows how closely he has adjusted his production from year to year to meet expected changes in the price of hogs.

Furthermore this farmer, like the men previously discussed, regulates his production and marketing so as to sell on the high seasonal markets. He has part of his sows farrow in March and others farrow a

month or two later. The March pigs are sold at 6 months of age on the following September market, and the May pigs are sold the following March and April at 11 months of age. The March pigs weigh 160 to 180 pounds when sold in September. In 1925 he received \$13.75 a hundred weight for them.

The fall pigs are usually farrowed in August or September and are sold either the next April or in July and August, when they weigh around 300 pounds. The time of selling the fall pigs varies with the market

TABLE 8.—ANNUAL ADJUSTMENTS IN SOWS BRED ON FARM No. 3

| Year | Number of sows bred the previous fall <sup>1</sup> |
|------|--|
| 1916 | 12   |
| 1917 | 19   |
| 1918 | 29   |
| 1919 | 32   |
| 1920 | 21   |
| 1921 | 26   |
| 1922 | 36   |
| 1923 | 32   |
| 1924 | 35   |
| 1925 | 13 <sup>2</sup>                                    |
| 1926 | 28   |

<sup>1</sup>About one-half as many sows are bred for fall litters as for spring litters each year.

<sup>2</sup>In 1925 this farmer had expected to breed 30 sows but the hogs got pneumonia and he sold 16 or 17 gilts.

situation and with the price of corn. If the price of corn is comparatively high, he sells at lighter weights in April, but if corn is cheap and hog prices favorable, he feeds out longer and sells in either July or August, depending upon the market at the time.

This farmer plans to feed all of his corn. He figures that by producing efficiently he can make as much out of his corn by feeding it to hogs, even if hog prices are low, as he can by selling corn. In such situations, however, he feeds out to lighter weights.

Thus in addition to being an efficient producer of hogs, this farmer also adjusts his production somewhat from year to year to meet expected price changes, sells on the high seasonal markets, and feeds out to heavy or light weights, depending upon the relative price of corn and hogs. In other words, he adjusts his production and marketing to take advantage of both favorable and unfavorable situations and tries to turn each to his own advantage.

Practices similar to these we have been discussing on the above three farms are followed on numerous other farms in Illinois. Discussion

of further illustrations, however, would be largely a repetition of what has been said. Even if we were to cite practices of successful producers varying somewhat from those we have just been discussing, no material gain would result. This is true because they have as their chief aim the same objective, namely, to so adjust production and marketing as to hit the favorable markets and avoid the unfavorable ones as often as possible.

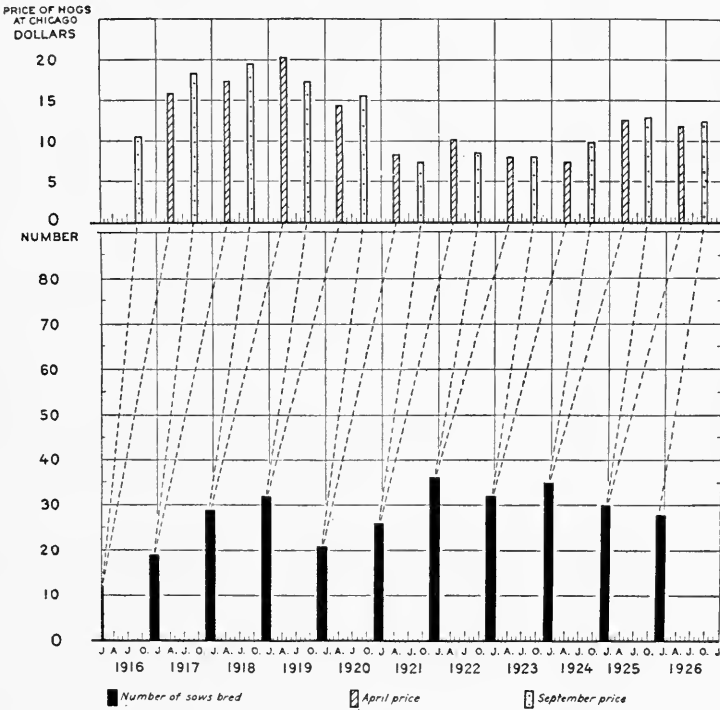


FIG. 17.—HOW A THIRD ILLINOIS FARMER HAS SUCCEEDED IN BRINGING HOG PRODUCTION INTO LINE WITH THE BETTER MARKETS

Like Farmer No. 2 this farmer sells hogs in both spring and fall. He does not plan to shift very widely from year to year but he sells at varying weights, feeding out to heavier weights when the price of corn is favorable, and to lighter weights when it is less favorable.

Variations in practice are to be expected on individual farms, for each farm has conditions peculiar to itself and each farmer knowing these conditions will select those lines of production and adopt those practices which seem to him to best fit his peculiar situation and which give promise of returning the greatest profit.

### PRACTICES OF THE MAJORITY OF FARMERS

The only measure we have of the manner in which the majority of farmers vary their hog production from year to year is the variation in the receipts of hogs at the central markets. The spring pig crop usually begins moving to market the latter part of September and continues thru the following April.

Now farmers who produce hogs coming to market at this time each year have to decide from 10 to 15 months in advance upon how many sows they will breed to farrow in the spring. If we take the total receipts from September to April each year as representing the spring pig crop, and assume that an average size of litter per sow was raised and brought to market, then a rough estimate of the number of sows bred for spring litters each year can be secured.<sup>1</sup> A comparison between such estimates and the average price received for the pigs resulting from that breeding will give an indication of how the majority of farmers have adjusted their production from year to year and, further, the effect such adjustments had on the price of hogs 10 to 15 months later.

Fig. 18 has been constructed in this way. It shows the relation between the estimated number of sows bred for spring litters each year by the majority of farmers<sup>2</sup> and the average price for which the animals resulting from that breeding sold on the Chicago market starting with the next September and running thru the following April. With the exception of only three or four years out of this whole period, there was an inverse relationship between the estimated number of sows bred and the prices received for the hogs resulting from that breeding 10 to 15 months later.

This practice of the group is diametrically opposed to the practices of the three farmers which were discussed above. Whereas they adjusted their production so as to have few hogs to sell when the price was low and more hogs to sell when the price was high, the group had many hogs to sell when the price was low and few hogs to sell when it was high. In

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<sup>1</sup>Of course an estimate thus obtained is not strictly accurate. It assumes that the September to April receipts include only pigs farrowed in the spring; also that the average size of litter is the same from year to year. The receipts include, as a matter of fact, both sows and stags in addition to the pigs farrowed in the spring, and the assumption consequently may be in error to the extent this is true. However, it may be that the gilts and boars saved out of the spring pig crop to be used for breeding animals for the next year's crop are as large in number as the old sows and stags included in the receipts; hence the receipts from September to April may measure quite closely after all the spring pig crop. While there would be expected to be some difference in numbers from year to year, these differences would tend to average out over a period of years.

<sup>2</sup>An average litter of  $4\frac{1}{2}$  pigs was assumed to be raised and brought to market, and this divided into the receipts for the period indicated each year gives a rough estimate of the number of sows bred.



other words, the three successful producers capitalized on the mistaken estimates of the majority of producers and had their hogs ready to market when they stood the greatest chance of realizing good returns from them. Furthermore they were able to sell their hogs at favorable prices in April and September because the majority of other farmers were not selling many hogs then.

Obviously if the majority of farmers attempted to market their hogs in the same way as the more successful group, they would not meet with the same results. This is true because as soon as they changed their present practice of selling in the late fall and winter months and

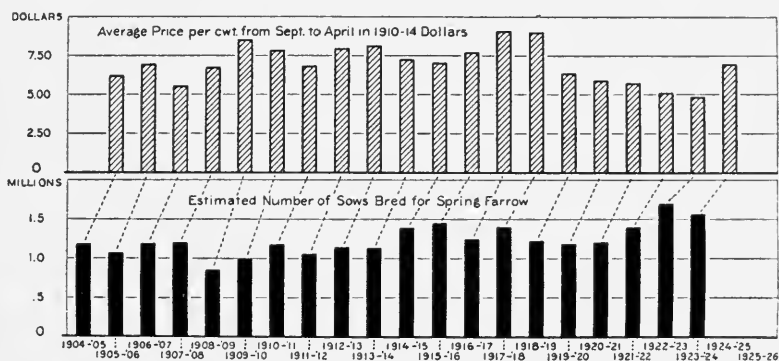


FIG. 18.—HOW THE MAJORITY OF FARMERS HAVE ADJUSTED THEIR HOG PRODUCTION

When the price of hogs is low, the majority of farmers have more hogs to sell than when it is high, and when the price is high they have fewer to sell.

begin to sell in April and September, the April and September prices of hogs would fall and the prices in the fall and winter would rise. Or in other words, the high seasonal markets would shift to the winter and summer months, and the low markets would come in the spring and fall. If such a shift were made, these three farmers, and many others who do the same thing, would doubtless make a shift in their present methods and practices and plan their breeding and marketing so as to have their hogs come to market in the late fall and winter months and in the summer.

It is believed that the practices of the better informed farmers would become more general if the relation between production and price and differences in seasonal markets were more generally understood. Our concern then is not so much to suggest what the successful producers should do or should not do. They are likely to do that which will be most advantageous for them from time to time anyway.

The question is rather, What may a much larger group of farmers do, from a marketing standpoint, to make hog production more generally profitable?

To answer this question will involve a consideration of the possibilities of "smoothing out" the hog-price cycle, and of the practices which the majority of farmers can adopt so as to avoid or prevent, in some measure, these periodic shiftings of hog prices up and down.

#### POSSIBILITIES OF SMOOTHING OUT THE HOG-PRICE CYCLE

In previous pages we have discussed in considerable detail the reasons for the periodic shifting up and down of hog prices. While these shifts are due to a number of things, the chief cause, we have seen, is the tendency for farmers to go into hog production too heavily in periods of high prices and to curtail too much in periods of low prices. Or in other words, the farmers themselves are in large measure responsible for these gluts and depressions. From this it follows that they must plan their production differently if they expect to smooth out or minimize their effect. What then are the possibilities of doing this, and what practices would have to be followed to accomplish it?

The present practice of the farmers of Illinois and other middle-western states of having their pigs farrowed in the spring and summer months and marketed in the late fall and winter months did not develop just by chance. In having their pigs farrowed in the spring, farmers get away from winter hog production. When pigs farrow in the winter, they are more trouble, require better buildings and equipment and more care and attention. Furthermore pigs farrowed in the winter and put on the early market in the fall have to be fed out on old corn, and this adds to the expense of production. Also, the number of pigs saved will probably be smaller in the winter than in the summer.

These considerations have probably had much to do in determining the choice of farmers for producing hogs in the spring. However, in having the pigs farrowed in the spring and sold in the late fall and winter months, they hit the low markets and must accept a lower price for them. It is for this reason that it would be more profitable, probably, for many more farmers to sell on the September and April markets. While this would tend to smooth out the seasonal differential, and make prices somewhat less favorable for farmers who sell at that time, it also would cut down the number marketed in the late fall and winter months and thereby improve the prices received by the majority of producers, who sell the major portion of their hogs at that time.

This, however, is only one phase of the adjustment problem. Another phase, and probably a more important one, is that of *balancing*

*up production* to coincide more closely with changing price conditions. Instead of looking so much at the relationship between corn and hog prices at the time of breeding as they have in the past, farmers should look more to the future, to what the situation is likely to be when the hogs are being fed out and marketed. That is, they should be influenced more by relationships which likely *will* exist between corn and hog prices, than by those which have prevailed in the immediate past or exist at the time of breeding.

When hog prices are very high, farmers usually should not go so heavily into hog production but should hold off somewhat and try to get in later when fewer hogs are coming to market. The relationship between corn and hog prices may be favorable at the time of breeding for next year's litters, yet by the time these hogs get to market the relationship may have changed completely. Hence by going into production heavily without regard to the future, farmers simply run a very heavy risk of adding to a supply already adequate and the result is a further drop in price.

It seems to be the psychology of hog producers to think when hog prices are high that they will continue high indefinitely, and likewise when they are low, that they will be low for some time. This short-sighted viewpoint is largely responsible for the big "ups and downs" in the market. If, therefore, farmers would have more stability in the market, they must adjust their production more closely to changing economic conditions.

There are those who believe that the whole farming business, hog production along with the rest, should be kept definite and fixed. That is, they believe farmers should grow about the same acreage of the same crops, and keep about the same number of each class of livestock, from year to year. They feel that if farmers will get into a definite system of farming and stick to it, we will have much greater stability in agricultural prices.

Such a static plan of production obviously assumes that the demand for agricultural products also will remain constant from year to year. Of course, we know that demand does not and will not remain constant for long at a time. We are living in a dynamic society in which the forces making up both demand and supply are in a constant state of flux. Economic relationships are constantly changing. The fact that consumers will take a certain amount of agricultural products at one time at a particular price does not mean that they will take the same amount at another time at the same price. They increase and decrease their purchases as their desires, abilities, and opportunities for making these purchases increase and decrease. So adjustments must necessarily be

made from time to time if there is to result any reasonable degree of balance between supply and demand.

It is possible to make the necessary adjustments in hog production from year to year without disrupting other enterprises in the farm organization to any great extent. Such a plan of production does not mean that a farmer should or would be "jumping in and out" of hog production from year to year. The three men cited above changed their production rather widely from year to year, yet none of them went completely out any year. Such a radical change would not be necessary, and likely would prove unprofitable. If each farmer, or the majority of farmers, would adjust his hog production more in the light of probable future prices than on the basis of past or prevailing prices, only a small variation in production would be necessary to bring about greater stability in hog prices. The important thing to do is to adjust at the strategic time. With the large amount of information now available and becoming available in increasing amounts, on the market outlook, intentions to breed, pigs farrowed and saved, etc., the farmer has the means of determining, with a fairly high degree of accuracy, when is the strategic time to change. The greater the accuracy with which this is done the more stable prices will become.

In conclusion, then, if the Illinois farmer would have hog production become more profitable, he will find it to his advantage, in addition to producing efficiently, to:

1. Adjust his production from year to year according to the outlook for hog prices rather than be influenced too much by past prices or by prices prevailing at time of breeding.

2. Take into account changes from year to year in price relationships between hogs and other enterprises such as cattle, sheep, corn, etc., and select from the alternative lines of production one or more which give promise of yielding the greatest net return to the farm business as a whole.

3. Sell hogs, in so far as costs and prices justify, in those months when hog prices usually are highest.

4. Vary the weight to which hogs are fed out and marketed according to the relationship between corn and hog prices.

## STATISTICAL APPENDIX

In the foregoing discussion reference has been made from time to time to statistical studies which were used as a basis for the discussion. Emphasis, however, was placed on the application of the results secured rather than on the particular statistical methods used in arriving at the results. Yet there may be some readers who are concerned as much or more with the method of analysis used, as with the results secured. It is for these readers that this statistical appendix is included.

Part I of the bulletin, which discusses the factors determining the price of hogs, was based on a multiple correlation analysis made by Messrs. Ezekiel and Haas of the Bureau of Agricultural Economics, U. S. Department of Agriculture. The methods of analysis employed by them have been discussed in detail in U. S. Department of Agriculture Bulletin 1440 and will not be repeated here.

Parts II and III of this bulletin, dealing with the elasticity of the supply of hogs, is based on a statistical study made by the writer, and it is the methods employed in that analysis which will be discussed in this Appendix.

### THEORETICAL BASIS

Back of a statistical analysis such as this must lie considerable economic theorizing. Numerous assumptions and hypotheses have to be made. In fact the whole "set-up" of the analysis is more economic than statistical. The success of the statistical analysis consequently is in large part dependent upon the reasonableness of the assumptions and the accuracy with which the economic analysis is made.

Variations in receipts of hogs in the terminal markets indicate that the production of hogs fluctuates from year to year. Our problem is to ascertain and explain the causes for these annual fluctuations in production. Why is it few hogs are produced some years and many hogs are produced other years? Or, what are the factors which cause farmers to respond in their production of hogs as they do?

In attempting to isolate the factors responsible for these variations in production numerous hypotheses and assumptions were made, chief of which are:

1. That fluctuations in hog production are in large measure the result of conscious efforts of farmers and to a lesser extent due to conditions over which they have no control.

2. That farmers as a group tend to engage in that line or those lines of production which *they believe* will return them the greatest net profit for the resources at their command. (This is not to say that they always *do* engage in that line of production which returns the greatest net profit.)

3. That hog farmers not only weigh the advantages and disadvantages of opportunities for profit in alternative lines of production open to them but that they will be induced to go more heavily or less heavily into the particular line or lines of production in which there is the greatest apparent comparative advantage.

4. That farmers in different type-of-farming areas will not respond in their hog production to changes in given factors in the same way, for the reason that they are producing under different conditions and financial circumstances.

5. That the important factors influencing production (receipts) from year to year and the relative importance of each factor upon receipts can be ascertained and measured by multiple correlation analysis.

6. That having found the quantitative relationships subsisting between receipts of hogs at Chicago and the various factors influencing receipts under given conditions in the past, it would be theoretically possible, general economic conditions remaining the same, to forecast the receipts coming to Chicago in the immediate future with a fair degree of accuracy.

### THE SERIES

With these assumptions and hypotheses in mind our next problem is to measure the quantitative effect of the various factors which theoretically are assumed to have an influence upon hog production. Before this is possible, however, it first is necessary to select data giving a continuous series over a period of years for each factor and further, to get the data in a suitable form for statistical treatment. The period selected for the analysis runs from 1898 to 1916.

### CHARACTER AND LIMITATION OF DATA

Receipts of live hogs at Chicago are used as an index of the production of hogs. This series is not quite so reliable an index of receipts as are receipts under inspected slaughter. The reason the latter is not used is that data back of 1907 on inspected slaughter are not available and a series covering earlier years is desired in order to avoid going into the war years.

Also the objection may be raised that receipts thus taken are not a fair index of production because they include, in addition to actual pigs farrowed and marketed during the year, old sows, stags, and boars. While possibly an error may arise in this connection, it probably is not very large, as the young gilts and boars kept for breeding stock are taken out of the current year's production and probably offset the number of old breeding stock sent to market.

The prices of medium to choice heavy hogs, No. 2 mixed corn, and 1200 to 1500-pound steers at Chicago are taken and treated as described below. The data on loss from disease, percentage of non-merchantable corn, and number of breeding sows on farms are taken from the reports of the Bureau of Crop Estimates. The climatic data for calculating the index of climate are taken from U. S. Weather Bureau reports.

### DESCRIPTION OF SERIES

#### (Dependent Variable)

##### Symbol

$X_1$ ..... *Receipts of hogs at Chicago starting in September of each year and running thru the following April. Calculated for the period 1898 to 1916 and the percentage changes in receipts from one year to the next calculated and used as the dependent series.*

#### (Independent Variables)

$X_2$ ..... *December corn-hog ratio. Calculated by dividing the value of 100 pounds of hogs at Chicago in December by the value of 11.4 bushels of corn in the same month.*

$X_3$ ..... *Average June to November corn-hog ratio. Calculated by dividing the average value of 100 pounds of live hogs from June to November by the average value of 11.4 bushels of corn for the same period at Chicago.*

$X_4$ ..... *Average January to March corn-hog ratio. Calculated by dividing the average value of 100 pounds of live hogs from January to March by the average value of 11.4 bushels of corn for the same period at Chicago.*

$X_5$ ..... *Index of climate at farrowing time. Composite of three factors: (1) departure of monthly temperature from normal, (2) number of rainy days in each month, (3) number of sudden changes in temperature (a sudden change in temperature reckoned as a drop in temperature of 10 degrees or more to a level of 10 degrees above zero or below.) Readings taken at Monmouth, Illinois, Iowa City, Iowa, and Lancaster, Wisconsin, in February, March, and April, from 1897 to 1925. With these data available the first problem was to compute a regional monthly index of temperature, rainfall and sudden changes. The readings for each factor each month for each location or state were combined according to the relative number of hogs sent to Chicago from each state. Thus the February regional index of departure of temperature from normal was computed by multiplying the February normal departure at Monmouth, by the relative number of hogs sent to Chicago from Illinois, and similarly the February departures from normal at Iowa City and Lancaster were multiplied by the relative number of hogs sent to Chicago from Iowa and Wisconsin respectively: the three products summed giving the February regional index of departure of temperature. In a similar way regional*

indexes were computed for the other factor in February as well as for the other two months.

These monthly regional indexes for temperature, rainfall, and sudden changes were then combined into annual indexes of temperature, rainfall and sudden changes. Recognizing that a February change in temperature, rainy days or sudden changes should not have as much weight in the final index as a change in each of these factors in March and April, it was necessary to devise some scheme of weighting which would take cognizance of the difference. It was assumed that a logical method of weighting each month would be on the basis of the relative number of pigs farrowed in each month. This was done. This gave annual indexes of temperature, number of rainy days and number of sudden changes for the region.

Before combining these three indexes into the final index of climate it became necessary:

1. To correct them for differences in variability. It was noted that the temperature index was much more variable than the other two and unless this variability were corrected for, it would have a disproportionate influence in the final index. Accordingly the standard deviations of the three indexes were computed, and considering the temperature series as a base, the other two series were corrected to conform to it, that is, made to have the same variability.

2. To determine the weights to use for each of the factors, temperature, rainy days, and sudden changes.

The three indexes corrected for variability were considered as independent variables along with the other independent variables and correlated with receipts as the dependent variable in a linear multiple-correlation solution. The net regressions obtained in this solution for each were used as the weights in combining the three into the final index. These were as follows: temperature + .02938, rainy days —.03974, and sudden changes —.27525.

The final index thus secured was negative for some years and positive for others. In order to get rid of negative signs, 100 was added to each annual index. The resulting indexes were then turned into percentages by taking the percentage change in the index from year to year.

- $X_6$ ..... *Time or trend* was taken as an ascending arithmetic series from 1898 to 1916; that is, as 1, 2, 3, 4, and so on, up to 18, the total number of years covered in the study.<sup>1</sup>
- $X_7$ ..... *December steer-hog ratio.* Calculated by dividing the value of 100 pounds of heavy hogs at Chicago in December by the value of 100 pounds of 1200 to 1500-pound steers at Chicago for the same period.
- $X_8$ ..... *Change in percentage of non-merchantable corn in Illinois and Iowa from previous year.* Calculated by taking the percentage of non-merchantable corn each year in each state and weighting each according to the average size of crop in each state from 1909 to 1913. The resulting products were then totalled and turned into percentages by calculating the percentage changes from year to year.
- $X_9$ ..... *Disease loss.* Crop estimates data showing estimated loss from disease each year in Iowa, Illinois, Minnesota and Wisconsin were totalled and turned into percentages by calculating percentage changes from year to year.
- $X_{10}$ ..... *Estimated number of breeding sows on farms.* Data taken from Reports of Bureau of Crop Estimates were totalled for Iowa, Illinois, Wisconsin, and Minnesota, and then the percentage change in numbers from year to year calculated.

<sup>1</sup>The error in eliminating secular trend and seasonal variation before correlating time series. B. B. Smith. Jour. Amer. Statis. Assoc. 20 (n.s. 152), 543-545. 1925.



It will be noted that percentage changes in receipts from year to year have been computed instead of deviations from trend. Since we are attempting to measure the factors which cause farmers to react as they do from year to year, it is reasonable to suppose that they will react more quickly to a change in a condition with respect to the immediate past than they will with respect to a long-time trend or norm. That is, they remember more vividly situations and relationships in the immediate past.

TABLE 1.—THE SERIES

| Sept.<br>to Apr.<br>of year | Corn-hog ratio                 |                                    |                                      | Index of<br>climate<br>Feb. to<br>Apr.<br>first<br>year | Time           | Hog-<br>steer<br>ratio<br>Dec.<br>pre-<br>ceding<br>year | Percent<br>non-mer-<br>chantable<br>corn pre-<br>ceding<br>year | Disease<br>loss | Number<br>of<br>breeding<br>sows on<br>farms<br>first<br>year | Receipts<br>of hogs<br>at<br>Chicago |
|-----------------------------|--------------------------------|------------------------------------|--------------------------------------|---|----------------|--|---|-----------------|---|--------------------------------------|
|                             | Dec.<br>pre-<br>ceding<br>year | Av. 6<br>months<br>June to<br>Nov. | Av. Jan.<br>to Mar.<br>first<br>year |   |                |  |   |                 |   |                                      |
|                             | X <sub>2</sub>                 | X <sub>3</sub>                     | X <sub>4</sub>                       | X <sub>5</sub>  | X <sub>6</sub> | X <sub>7</sub>   | X <sub>8</sub>  | X <sub>9</sub>  | X <sub>10</sub>   | X <sub>11</sub>                      |
| 1898-99...                  | 113                            | 117                                | 119                                  | 93  | 1              | 78   | 42  | 94              | 91  | 105                                  |
| 1899-1900...                | 83                             | 105                                | 93                                   | 110   | 2              | 67   | 235   | 48              | 97  | 91                                   |
| 1900-01...                  | 115                            | 113                                | 127                                  | 87  | 3              | 68   | 71  | 333             | 100   | 101                                  |
| 1901-02...                  | 110                            | 110                                | 123                                  | 113   | 4              | 91   | 64  | 45              | 97  | 109                                  |
| 1902-03...                  | 84                             | 98                                 | 94                                   | 93  | 5              | 105  | 150   | 117             | 99  | 84                                   |
| 1903-04...                  | 109                            | 104                                | 138                                  | 112   | 6              | 120  | 248   | 93              | 101   | 104                                  |
| 1904-05...                  | 95                             | 98                                 | 93                                   | 72  | 7              | 94   | 111   | 77              | 95  | 98                                   |
| 1905-06...                  | 86                             | 89                                 | 97                                   | 131   | 8              | 95   | 35  | 131             | 98  | 102                                  |
| 1906-07...                  | 93                             | 89                                 | 124                                  | 94  | 9              | 98   | 95  | 102             | 102   | 91                                   |
| 1907-08...                  | 119                            | 112                                | 137                                  | 86  | 10             | 108  | 56  | 132             | 106   | 112                                  |
| 1908-09...                  | 68                             | 88                                 | 69                                   | 119   | 11             | 88   | 442   | 74              | 96  | 101                                  |
| 1909-10...                  | 84                             | 75                                 | 90                                   | 98  | 12             | 90   | 39  | 92              | 97  | 70                                   |
| 1910-11...                  | 116                            | 113                                | 130                                  | 113   | 13             | 124  | 194   | 121             | 93  | 116                                  |
| 1911-12...                  | 140                            | 131                                | 136                                  | 94  | 14             | 124  | 37  | 246             | 115   | 119                                  |
| 1912-13...                  | 79                             | 88                                 | 85                                   | 92  | 15             | 85   | 187   | 112             | 92  | 90                                   |
| 1913-14...                  | 128                            | 101                                | 141                                  | 106   | 16             | 82   | 78  | 121             | 98  | 108                                  |
| 1914-15...                  | 97                             | 105                                | 116                                  | 84  | 17             | 92   | 161   | 70              | 97  | 99                                   |
| 1915-16...                  | 96                             | 97                                 | 81                                   | 128   | 18             | 81   | 63  | 57              | 104   | 123                                  |

The use of first differences also does away with the necessity of computing trends, and hence eliminates errors arising from the use of erroneous trends. Trends computed for pre-war years may be used with considerable confidence. When these trends are projected into the war and post-war periods, however, they must be used with much more caution. Sufficient time has not elapsed since the war to determine if the trends in the pre-war years are being maintained on the same level in the post-war years.

A part of the change in prices from year to year is due to changes in the value of money. Since there is no good reason for assuming that there is a relationship between changes in hog production and changes in the value of money, the proportion of the change in the price due to this factor should be eliminated. The usual method of correcting a price series for the price level is to divide the particular price by an index

number of all commodity prices. Since ratios rather than actual prices are used in this analysis, this correction is unnecessary.

Having assembled and tested qualitatively (by dot charts) the various factors which appear to be closely related to receipts of hogs, our next problem was to determine the quantitative relations subsisting among these factors. Qualitative analyses are important in testing out factors and suggesting relationships, yet they fall short in showing the *degree* of relationship existing among variables. For this purpose a quantitative measure of relationship is needed.

Gross or zero order correlation between two variables determines what values of one variable may be expected to accompany given values of the other, and further shows how close the relationship is. In studies in which the changes in one variable are the result of unit changes in a single other variable the coefficient of gross correlation gives satisfactory results. However, there are few problems in which such a relationship exists. It usually happens, particularly in economic data, that changes in the dependent variable are the result, not of a single independent variable, but of numerous independent variables operating simultaneously. For such problems gross correlation is inadequate. The method of multiple and partial correlation has been devised for problems of this kind.

In analyzing results affected by a large number of different factors, the method of partial correlation is about the only one which gives valid and definite quantitative results. In the method devised by Messrs. Tolley and Ezekiel<sup>1</sup> each record is considered as an observation equation of the form:

$$X_1 = a + b_{12.3456 \dots n} X_2 + b_{13.2456 \dots n} X_3 + b_{14.2356 \dots n} X_4 + b_{15.2346 \dots n} X_5 + b_{16.2345 \dots n} X_6 + \dots$$

In which  $X_1, X_2, X_3, X_4$ , etc., are the known quantities and  $a, b_{12.3456 \dots n}, b_{13.2456 \dots n}, b_{14.2356 \dots n}$ , etc., the unknown quantities to be determined.

There is one such equation for each set of observations. Since there is no one set of values of the unknowns which will satisfy all the equations, it becomes necessary to find that set of values which *most nearly* satisfies all the equations. If we assume that the set of values which makes the sum of the squares of the residuals a minimum is the set which most nearly satisfies all the equations, then the unknowns can be found by the formation and solution of normal equations. The normal equations formed from such observation equations are of the form:

<sup>1</sup>A method of handling multiple correlation problems. H. R. Tolley and M. J. B. Ezekiel. Jour. Amer. Statist. Assoc. 18 (n.s. 144), 993-1003. 1923.

$$\begin{aligned} \Sigma (X_1) &= Na + \Sigma (X_2) b_{12.34 \dots n} + \Sigma (X_3) b_{13.24 \dots n} + \Sigma (X_4) b_{14.23 \dots n} + \\ \Sigma X_1 X_2 &= \Sigma (X_2) a + \Sigma (X_2)^2 b_{12.34 \dots n} + \Sigma (X_2 X_3) b_{13.24 \dots n} + \\ &\quad \Sigma (X_2 X_4) b_{14.23 \dots n} + \\ \Sigma X_1 X_3 &= \Sigma (X_3) a + \Sigma (X_2 X_3) b_{12.34 \dots n} + \Sigma (X_3)^2 b_{13.24 \dots n} + \\ &\quad \Sigma (X_3 X_4) b_{14.23 \dots n} + \\ \Sigma (X_1 X_4) &= \Sigma (X_4) a + \Sigma (X_2 X_4) b_{12.34 \dots n} + \Sigma (X_3 X_4) b_{13.24 \dots n} + \\ &\quad \Sigma (X_4)^2 b_{14.23 \dots n}. \end{aligned}$$

There will be as many normal equations as there are unknown quantities to be determined and they are solved as ordinary simultaneous equations for the unknown quantities of,

$$a, b_{12.34 \dots n}, b_{13.24 \dots n}, b_{14.23 \dots n}, \text{ etc.}$$

Following the method sketched above, normal equations were formed and solved for the unknowns. The results were as found in Table 2.

EXPLANATION OF RESULTS IN TABLE 2

It will be noted that there is a considerable range in the size of the coefficients of net regression; also that some of them are positive and others negative in sign. These coefficients of net regression show the amount of change in the dependent variable associated with a unit change in each of the independent variables.

Thus the table shows that when there was a 1 percent change in  $X_2$  (the December corn-hog ratio) from normal, there was .41405 percent change in receipts of hogs at Chicago from the preceding year. In the case of  $X_9$  (loss from disease), on the other hand, an increase of 1 percent in disease loss resulted in a decrease of —.03064 percent in receipts.

TABLE 2.—RELATIVE EFFECT OF VARIOUS INDEPENDENT FACTORS UPON RECEIPTS (ASSUMING LINEAR REGRESSION)<sup>1</sup>

| Variable       | Coefficient of net regression |  | Coefficient of determination (percent) |
|----------------|-------------------------------|--|--|
|                | Of $X_1$ on variable          |  |  |
| $X_2$ .....    | .41403                        |  | 35.4                                   |
| $X_3$ .....    | .61526                        |  | 38.1                                   |
| $X_4$ .....    | — .17700                      |  | — 11.5                                 |
| $X_5$ .....    | .29517                        |  | 11.5                                   |
| $X_6$ .....    | .12407                        |  | 6.8                                    |
| $X_7$ .....    | — .04939                      |  | — 1.73                                 |
| $X_8$ .....    | .00364                        |  | — .4                                   |
| $X_9$ .....    | — .03064                      |  | — 2.2                                  |
| $X_{10}$ ..... | .18575                        |  | 3.6                                    |

<sup>1</sup>The coefficient of multiple correlation  $R = .89$ .

The relative effect of the other independent variables upon receipts may be obtained in a similar way. The reader should remember that the coefficients of net regression in every case are in percentage and indicate the percentage change in receipts accompanying or resulting from a 1 percent change in each independent variable.

In the second column of Table 2 are shown the coefficients of determination for each one of the independent variables. These coefficients of determination show approximately the relative effect of each of the independent variables upon receipts. Since their meaning and method of computation may not be generally understood, it may be well to discuss them briefly.

#### MEANING AND SIGNIFICANCE OF COEFFICIENTS OF DETERMINATION

The ideal method of scientific investigation is to hold constant all the factors affecting a particular resultant except the one under direct observation, a measure of whose effect is desired. While in the natural sciences this condition may be fully realized, in the social sciences it is an ideal rarely if ever attained. It usually happens that, instead of having to measure the effect of one factor in which the effect of all other factors has been eliminated, the investigator, dealing with economic problems, has to attempt to measure the influence of a single factor in which all other factors are operating simultaneously. Further, these independent or "causal" factors may be very closely interrelated and the net influence of each factor consequently be very difficult to determine. About the only method of analysis for problems such as this is that of multiple and partial correlation. The coefficient of multiple correlation, however, will show only the degree of relationship subsisting between the dependent variable and all the independent variables, that is, it gives the resultant of all connecting paths of influence. Another measure is needed which will show the direct influence along each separate path in such a multi-variable problem. Dr. Sewall Wright<sup>1</sup> derived such a measure which he termed a path coefficient. The path coefficient is really the coefficient of net regression expressed in terms

of unit standard deviation. Thus  $b_{12.34 \dots n} \frac{\sigma_2}{\sigma_1} = \beta_{12.34 \dots n}$  where  $b_{12.34 \dots n}$  is the coefficient of net regression,  $\sigma_2$  and  $\sigma_1$ , the respective standard deviations and  $\beta_{12.34 \dots n}$  the path coefficient.

B. B. Smith<sup>2</sup> has shown how this coefficient of determination could be derived directly from a least-square treatment of multiple correlation. Thus:

<sup>1</sup>Correlation and causation. Jour. Agr. Res. 20, 557-585. 1921.

<sup>2</sup>Forecasting the acreage of cotton. Jour. Amer. Statist. Assoc. 20 (n.s. 149), 31-47. 1925.

$$d_{12.34 \dots n} = \frac{b_{12.34 \dots n} p_{12}}{\sigma_1^2} \text{ where}$$

$d_{12.34 \dots n}$  = coefficient of determination of variable 2 by variable 1 holding constant variables 3, 4, 5, etc.,

$b_{12.34 \dots n}$  = the net regression of variable 1 on 2,

$p_{12}$  = gross product moment of variables 1 and 2,

$\sigma_1^2$  = squared standard deviation of dependent variable 1.

The coefficient of determination of each of the other independent variables is derived in the same way. The total determination of all the independent variables combined is the sum of their percentage determinations, or it is equivalent to the square of  $R$ , the coefficient of multiple correlation.

While this method of deriving the coefficients of determination shows the relative net effect of each independent variable upon the dependent, it does not show how much of this determination is due directly to the variation in the particular independent alone and how much is due to variations in the other independents working thru it. Or in other words, it does not divide the total determination imputed to each independent into the amount of determination which is direct and the amount which is joint.

Mr. H. R. Tolley of the Bureau of Agricultural Economics, U. S. Department of Agriculture, has worked out a method (unpublished) showing how this determination is distributed as between the direct and joint effects. Thus:

$$\begin{aligned} d_{12.34 \dots n} &= r_{12} \beta_{12.34 \dots n} \\ &= p_{12} \cdot \frac{b_{12.34 \dots n}}{\sigma_1^2} \text{ since } \frac{p_{12}}{\sigma_1 \sigma_2} = r_{12} \text{ and} \end{aligned}$$

$$b_{12.34 \dots n} \frac{\sigma_2}{\sigma_1} = \beta_{12.34 \dots n}$$

$$\text{But } p_{12} = \sigma_2^2 b_{12.34 \dots n} + p_{23} b_{13.24 \dots n} + p_{24} b_{14.23 \dots n}$$

$$\text{Then } d_{12.34 \dots n} = \frac{p_{12} \cdot b_{12.34 \dots n}}{\sigma_1^2} = \frac{\sigma_2^2 b_{12.34 \dots n}^2}{\sigma_1^2} +$$

$$\frac{p_{23} b_{13.24 \dots n} \cdot b_{12.34 \dots n}}{\sigma_1^2} + \frac{p_{24} b_{14.23 \dots n} \cdot b_{12.34 \dots n}}{\sigma_1^2}$$

$$\text{But } \frac{\sigma_2^2 b_{12.34 \dots n}^2}{\sigma_1^2} = \beta_{12.34 \dots n}^2 \text{ and } p_{23} b_{13.24} b_{12.34} = r_{23} \beta_{13} \beta_{12}$$

since  $p_{23} = r_{23} \sigma_2 \sigma_3$

$$b_{13.24 \dots n} = \beta_{13.24 \dots n} \frac{\sigma_1}{\sigma_3}$$

$$b_{12.34 \dots n} = \beta_{12.34 \dots n} \frac{\sigma_1}{\sigma_2}$$

$$\text{Then } \frac{p_{23} b_{13.24 \dots n} b_{12.34 \dots n}}{\sigma_1^2} = \frac{r_{23} \sigma_2 \sigma_3}{\sigma_1^2} \frac{\beta_{13} \sigma_1}{\sigma_3} \frac{\beta_{12} \sigma_1}{\sigma_2} = r_{23} \beta_{13} \beta_{12}$$

Likewise,  $p_{24} b_{14.23 \dots n} b_{12.34 \dots n} = r_{24} \beta_{14} \beta_{12}$

Then finally,

$$d_{12.34 \dots n} = \beta_{12.34 \dots n}^2 + r_{23} \beta_{13} \beta_{12} + r_{24} \beta_{14} \beta_{12} + \dots$$

or in words, the coefficient of determination of variable 2 on variable 1 in which variables 3, 4, 5, etc., are held constant, is the sum of the square of the path coefficient,  $\beta_{12.34 \dots n}^2$  (the direct path of influence from 2 to 1), plus the sum of the joint paths of influence of variables 3 and 4 working thru variable 2, viz.,

$$r_{23} \beta_{13} \beta_{12} + r_{24} \beta_{14} \beta_{12}.$$

The sign of the direct determination will always be positive since it is equivalent to the square of the path coefficient. When the sum of the joint determinations is larger negatively than the direct determination, then the coefficient of determination will be negative.

It will be noted from Table 2 that some of the coefficients of determination are negative. This means that the tendency for each of these variables to cause the dependent variable to move positively with it is overshadowed or overpowered by the force of the other independent variables, causing it to move in the opposite direction; consequently the total determination due to this independent variable becomes negative. Table 3 shows the percentage determination due directly to each independent and the amount of joint determination resulting from the other variables working thru each one.

In the formation and solution of these normal equations there was assumed to be linear regression between the dependent and the various independent variables. That is, the amount of change in the dependent variable associated with a given change in the independent variable is constant for all values on the independent scale. Such an assumption it was felt, however, did not correspond to what one would

theoretically expect. The hypothesis was rather that receipts would not increase in a constant ratio with given increases in the corn-hog ratio, climatic conditions at farrowing time, etc., but would tend to slow up in the upper range. That is, when the corn-hog ratio became very high, it was believed that additional changes upward would not have the same influence upon receipts as such a change would have when the ratio was not so high, for the reason that some farmers will begin to curtail production somewhat thru fear of overdoing the thing and also because of the sheer inability of increasing production indefinitely because of limitations of capital, equipment, etc. In other words, it was felt that the curve of increase in receipts would begin to flatten out in the upper range and that the regression of receipts, upon some of the independent variables at least, would be curvilinear instead of linear.

TABLE 3.—COEFFICIENTS SHOWING THE PERCENTAGE (TOTAL, DIRECT, AND JOINT) DETERMINATION OF EACH INDEPENDENT VARIABLE ON  $X_1$  (LINEAR REGRESSION)

| Variable       | Total | Direct | Joint  |
|----------------|-------|--------|--------|
| $X_2$ .....    | 35.4  | 32.74  | 2.66   |
| $X_3$ .....    | 38.1  | 34.32  | 3.78   |
| $X_4$ .....    | -11.5 | 8.68   | -20.18 |
| $X_5$ .....    | 11.6  | 13.79  | -2.19  |
| $X_6$ .....    | 6.8   | 6.24   | .56    |
| $X_7$ .....    | -1.7  | .42    | -2.12  |
| $X_8$ .....    | -.4   | .08    | -.48   |
| $X_9$ .....    | -2.2  | 2.68   | -4.88  |
| $X_{10}$ ..... | 3.6   | .76    | 2.84   |

It will be noted that the relationship between  $X_7$ ,  $X_8$ ,  $X_9$ ,  $X_{10}$ , and  $X_1$  is of relatively little significance. For this reason these variables were dropped and only the other five used in the final solution.

The problem now became one of determining whether or not the relationships were curvilinear, and if so to measure them quantitatively. The method of determining the index of multiple curvilinear correlation worked out by Mr. Ezekiel of the Bureau of Agricultural Economics, U. S. Department of Agriculture<sup>1</sup> was followed.

#### MEANING AND METHOD OF COMPUTING THE INDEX OF MULTIPLE CURVILINEAR CORRELATION

Having obtained the constants in the multiple linear regression or "predicting" equation of the form  $X'_1 = a + b_2 X_2 + b_3 X_3 + b_4 X_4 +$

<sup>1</sup>A method of handling curvilinear correlation for any number of variables. Mordecai Ezekiel. Jour. Amer. Statis. Assoc. 19 (n.s. 148), 431-453. 1924.

. . .  $b_n X_n$ , residuals were calculated for each observation equation by the following formula:

$$e = X_1 - X'_1$$

or 
$$= X_1 - (a + b_2 X_2 + b_3 X_3 + b_4 X_4 + \dots + b_n X_n)$$

in which  $e$  = residual sought,  $X_1$  = original observation, and  $X'_1$  = estimate of  $X_1$  made by using the linear predicting equation. Thus each residual shows the extent to which each observed value of  $X_1$  differs from the value computed from the estimating equation.

Now if the true regression between  $X_1$  and the other independent variables is curvilinear rather than linear, all this equation can do is to show the linear relation subsisting between them, neglecting altogether the curvilinear effect. If the residuals as calculated above are plotted as vertical deviations from the net regression line of each of the independent variables arrayed on the dependent variable  $X_1$ , a curve drawn thru the average of the arrayed residuals will give an indication of the net curvilinear regression of each independent variable upon the dependent. This may be considered the first approximation of the true curvilinear regression. Using this curve, new residuals ( $e'$ ) were computed by the use of the formula—

$$e' = X_1 - (K' + F'(X_2) + F'(X_3) + F'(X_4) + \dots) \dots$$

in which  $F'X_2$ ,  $F'X_3$ ,  $F'X_4$ , etc., represent values read from the first approximation curve and the curve drawn thru the average of these arrayed residuals gave the second approximation of the true curvilinear regression between the dependent and each independent variable.

The second approximation curves were used to compute third residuals  $e''$  by the formula:

$$e'' = X_1 - K'' - F''(X_2) + F''(X_3) + F''(X_4) + \dots$$

and the new residuals used to ascertain the third curve approximating the true curvilinear regression as in the preceding case. The process might have been repeated and new residuals computed to still further correct the curves, but it was felt there would be little gained by further extension. Table 4 shows the values used in the final correlation.

The functional values in Table 4 are the curvilinear equivalents of the linear values of each independent variable and are the values determining the shape of the curve of regression in each case. They were read direct from the curves of regression of receipts upon each one of the independent variables.



TABLE 4.—FUNCTIONAL VALUES OF INDEPENDENT VARIABLES READ FROM THIRD APPROXIMATION CURVES AND USED FOR FINAL CORRELATION SOLUTION

| $F''X_2$ | $F''X_3$ | $F''X_4$ | $F''X_5$ | $F''X_6$ | $X_1^1$ |
|----------|----------|----------|----------|----------|---------|
| 109..... | 110      | 99       | 97       | 95       | 105     |
| 93.....  | 105      | 101      | 102      | 96       | 91      |
| 109..... | 109      | 99       | 97       | 97       | 101     |
| 107..... | 108      | 99       | 103      | 98       | 109     |
| 94.....  | 100      | 101      | 97       | 98       | 84      |
| 107..... | 105      | 99       | 102      | 99       | 104     |
| 99.....  | 100      | 101      | 101      | 100      | 98      |
| 95.....  | 92       | 101      | 116      | 100      | 102     |
| 98.....  | 92       | 99       | 97       | 101      | 91      |
| 110..... | 108      | 99       | 96       | 102      | 112     |
| 86.....  | 92       | 116      | 107      | 102      | 101     |
| 94.....  | 77       | 102      | 97       | 103      | 70      |
| 109..... | 109      | 99       | 103      | 104      | 116     |
| 112..... | 115      | 99       | 97       | 104      | 119     |
| 92.....  | 92       | 104      | 97       | 105      | 90      |
| 112..... | 103      | 99       | 100      | 106      | 108     |
| 101..... | 105      | 100      | 97       | 106      | 99      |
| 100..... | 99       | 107      | 116      | 107      | 123     |

<sup>1</sup> $X_1$  is the dependent variable, and the values shown for it represent actual percentage changes in receipts at Chicago.

Using the curvilinear equivalents of the independent variables  $X_2, X_3, X_4, X_5$  designated as:  $F''(X_2) F''(X_3) - F''(X_4) \cdot F''(X_5)$ , and using the linear function of  $X_6$  as the other independent, the following results were secured when correlating with  $X_1$  (receipts): The index of multiple correlation (corrected) was .983. Standard

$$\text{error of estimate} = \sqrt{\frac{\sigma_e^2}{\sigma_1^2}} = .0241 = 2.41 \text{ percent.}$$

The final estimating or "predicting" equation decoded and in terms of functional values becomes:

$$X_1 = .95626 F'' X_2 + .79962 F'' X_3 + 1.05910 F'' X_4 + 1.05714 F'' X_5 + .92089 F'' X_6 + 384.8491.$$

#### RELATIVE IMPORTANCE OF THE FACTORS DETERMINING SUPPLY

In Table 5 are shown the coefficients of net regression of receipts upon each independent variable and of each independent variable upon receipts; also the gross and net coefficients of correlation are shown. While the coefficients of net regression show the amount of change in the dependent variable accompanying or resulting in given changes in each independent variable and the coefficients of correlation show what the degree of relationship is, they do not show the amount of determination due to each factor.

In Table 6 are shown the coefficients of determination. It will be noted that in addition to the total determination is shown the amount of determination which is direct and the amount which is joint. They

have been computed in the same way as those shown in a former table (see page 553)

A little more than 70 percent (72.1 percent) of the variation in receipts of hogs at Chicago for the period from 1898 to 1916 could be accounted for by three corn-hog ratios "lagged" at varying periods.

TABLE 5.—COEFFICIENTS OF NET REGRESSION AND OF GROSS AND NET CORRELATION

| Variable    | Coefficient of net regression |                 | Coefficient of correlation of variable with $X_1$ |       |
|-------------|-------------------------------|-----------------|---|-------|
|             | Of $X$ on variable            | Variable on $X$ | Net   | Gross |
| $X_2$ ..... | .95626                        | .84720          | .90   | .60   |
| $X_3$ ..... | .79962                        | 1.05186         | .917  | .67   |
| $X_4$ ..... | 1.05910                       | .83327          | .802  | -.037 |
| $X_5$ ..... | 1.05714                       | .60890          | .939  | .39   |
| $X_6$ ..... | .92089                        | .70120          | .804  | .27   |

Apparently farmers are influenced in their breeding operations more by the relationship between corn and hog prices than by any other one thing. The relation between corn and hog prices in December at the

TABLE 6.—COEFFICIENTS SHOWING THE PERCENTAGE (TOTAL, DIRECT AND JOINT) DETERMINATION OF EACH INDEPENDENT VARIABLE ON  $X_1$  (CURVILINEAR REGRESSION)

| Variable    | Total | Direct | Joint  |
|-------------|-------|--------|--------|
| $X_2$ ..... | 36.9  | 37.20  | -.42   |
| $X_3$ ..... | 36.4  | 29.85  | 6.55   |
| $X_4$ ..... | - 1.2 | 11.28  | -12.48 |
| $X_5$ ..... | 18.7  | 23.65  | -4.95  |
| $X_6$ ..... | 6.7   | 6.13   | .57    |

time of breeding for spring litters and the relation for the six months preceding breeding had the greatest influence upon breeding operations. Climatic conditions at farrowing time was the third most important factor influencing receipts. In this analysis this factor accounted for about 18 percent of the variation in receipts.

The other factors, the relation between hog and steer prices, size of the corn crop or percentage of non-merchantable corn, number of sows available for breeding stock, etc., were of minor importance so far as this analysis indicated. While there was found to be some relationship between each of these factors and receipts, it was of negligible significance as compared with the important influence of the corn-hog ratios and climatic conditions at farrowing time. Table 3, page 557, shows the net effect of each upon receipts.

### ARE THE CORN-HOG RATIOS "INDEPENDENT FACTORS" OR ARE THEY THREE MEASURES OF THE SAME INFLUENCE?

Some doubt may have arisen in the mind of the reader whether the three corn-hog ratios are really independent variables or whether they are really three measures of the same thing. The answer to this involves largely what is meant by "independent variables."

Independence in the statistical sense may be viewed from the standpoint of (a) the relationship between a particular resultant and certain factor or factors assumed to influence this resultant, and (b) the relationship between one particular "causal" factor and other "causal" factors operating simultaneously. It is in the former sense, however, to which greatest significance is to be attached. In both senses there may be a gradation in relationship ranging from complete independence (no relationship) to complete dependence (perfect relationship.)

TABLE 7.—EFFECT UPON COEFFICIENTS OF CORRELATION AND DETERMINATION OF DROPPING CERTAIN OF THE CORN-HOG RATIOS

| Independent variables            | Dependent variable | Index of multiple curvilinear correlation | Coefficient of determination |
|----------------------------------|--------------------|---|------------------------------|
| $X_2, X_3, X_4, X_5, X_6, \dots$ | $X_1$              | .983                                      | .9750                        |
| $X_2, X_3, X_4, X_5, \dots$      | $X_1$              | .965                                      | .9305                        |
| $X_2, X_4, X_5, X_6, \dots$      | $X_1$              | .933                                      | .8706                        |
| $X_2, X_4, X_5, X_6, \dots$      | $X_1$              | .919                                      | .8453                        |

Where  $X_1$  = Receipts of hogs at Chicago.

$X_2$  = December corn-hog ratio lagged 9 to 12 months.

$X_3$  = Average June to November corn-hog ratio lagged 15 to 18 months.

$X_4$  = Average January to March corn-hog ratio lagged 1 to 9 months.

$X_5$  = Index of climate at farrowing time.

$X_6$  = Time or trend.

It is possible to have high gross correlation between a particular independent and dependent factor, yet when other independent factors are used, the net effect of the first independent factor be nil. This would arise in case there happened to be very high correlation between this particular factor and the other independent factors. It is because of this fact that coefficients of gross correlation must be accepted with caution.

When a particular variable is used in a multiple-correlation analysis, the inference is that this factor has a net influence on the dependent apart from and in addition to the other factors used. Or in other words, if when using this factor the coefficients of multiple correlation and determination are increased, then we may conclude that this factor is an independent factor. Conversely, if these coefficients are not increased when this factor is added, its net effect may be considered nil.

Using this as a criterion, an analysis was made of the question of whether the three corn-hog ratios are really independent factors, with the results observed in Table 7.

It will be noted from this table that the index of multiple curvilinear correlation and the coefficient of determination are reduced when any of the corn-hog ratios are dropped out. Or in other words, it is possible to explain a larger proportion of the variability in receipts using all three of the corn-hog ratios along with the other two factors than can be explained when any of the ratios are dropped.

#### EFFECT OF OATS-HOG RATIO, BARLEY-HOG RATIO, ETC., UPON RECEIPTS

In the context allusion was made to the possible effect which an oats-hog ratio, barley-hog ratio, and wheat-hog ratio would have upon receipts. The hypothesis, as set forth then, was that they likely would have no effect because they would be so highly correlated with the corn-hog ratio that when those inter-correlations were taken into account and corrected for, their net effect would be nil.

Recently Mr. E. M. Daggitt of the Bureau of Agricultural Economics of the U. S. Department of Agriculture has had occasion to test out the influence of these various ratios upon receipts of hogs at Chicago, and his results support the hypothesis made above.<sup>1</sup> He found there was a gross correlation between all these ratios and receipts of hogs at Chicago. The coefficients of gross correlation varied from .3 and .5 for the wheat-hog ratio and barley-hog ratio respectively to .75 for the oats-hog ratio. Considerable gross correlation was to be expected because hog prices are used in calculating each of these ratios and there is a close correlation between hog prices and hog receipts. But when these ratios were included, along with the corn-hog ratios and other factors influencing receipts, as independent variables in a multiple-correlation solution, and the intercorrelations determined and corrected for, it was found that the net influence of these ratios was nil. In other words, they did not increase the coefficient of multiple correlation beyond what it was when they were used, nor did they reduce the standard error of estimate, both of which would have been necessary if they had had an added effect.

#### DO CHANGES IN HOG PRICES AFFECT RECEIPTS EARLIER THAN CHANGES IN THE CORN-HOG RATIO?

The hypothesis has been advanced that changes in hog prices affect hog receipts earlier than do changes in the corn-hog ratio. A

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<sup>1</sup>Unpublished.

number of multiple-correlation analyses were made in order to test this out, also to determine if hog prices, lagged for longer periods and used as additional variables, along with the three corn-hog ratios and other variables, would make possible a more accurate estimate of receipts.

Assuming linear relations, hog prices (lagged first 20 months and then 23 months) were used as an additional variable and included along with the three corn-hog ratios (lagged 12 to 18 months, 9 to 15 months, and 6 to 12 months respectively), the index of climate, and trend, and were correlated with receipts. The results were as found in Table 8.

It will be noted that when hog prices, lagged for the periods indicated, are added as independent variables, the coefficient of correlation is increased from .88 to .882 when hog prices from November to March are used, and to .884 when January to April hog prices are used.

TABLE 8.—EFFECT UPON COEFFICIENTS OF CORRELATION AND DETERMINATION OF HOG PRICES LAGGED FOR LONGER PERIODS AS ADDITIONAL FACTORS

| Independent variables                   | Dependent variable | Coefficient of multiple correlation | Coefficient of determination |
|---|--------------------|-------------------------------------|------------------------------|
| $X_2, X_3, X_4, X_5, X_6$ .....         | X                  | .88                                 | .7780                        |
| $X_2, X_3, X_4, X_5, X_6, X_{12}$ ..... | X                  | .882                                | .7784                        |
| $X_2, X_3, X_4, X_5, X_6, X_{11}$ ..... | X                  | .884                                | .7822                        |

Where  $X_1$  = Receipts of hogs at Chicago.

$X_2$  = December corn-hog ratio, lagged 9 to 15 months.

$X_3$  = Average June to November corn-hog ratio, lagged 12 to 18 months.

$X_4$  = Average January to March corn-hog ratio, lagged 6 to 12 months.

$X_5$  = Index of climate at farrowing time.

$X_6$  = Trend or time.

$X_{11}$  = Hog prices (deflated) January to April, lagged 20 to 22 months.

$X_{12}$  = Hog prices (deflated) November to March, lagged 22 to 24 months.

While the use of hog prices, lagged as indicated, does increase slightly the accuracy with which an estimate of receipts might be made, the effect is so slight as to be practically negligible.

There is a gross correlation of .586 between receipts and hog prices lagged 20 to 22 months. When this factor is included as an independent variable along with other independent factors and the intercorrelations are determined and corrected for, the net coefficient of correlation drops to .13, indicating the small net effect it really has in addition to the other factors.

These results are of interest in indicating that changes in hog prices do seem to affect subsequent receipts earlier than do changes in the corn-hog ratio; also possibly in providing a basis for estimating receipts earlier than is possible when using the corn-hog ratios.

While it is possible to estimate receipts considerably earlier by using hog prices alone, the estimate is not very trustworthy. This is

indicated by the fact that when using hog prices (lagged 20 to 22 months) and trend as independent factors, and correlating with receipts, a coefficient of multiple correlation of only .623 is obtained. Or in other words, it is possible to explain only 38.81 percent of the variability in receipts by using these factors. This is better than a guess, of course, but does not give an estimate nearly so accurate as can be made when the corn-hog ratios are used.

### COEFFICIENT OF ELASTICITY OF SUPPLY OF HOGS IN CHICAGO MARKET

From the foregoing results and from the tables presented in the context, coefficients of elasticity of supply may be calculated at once. Elasticity of supply as used here may be defined as the relation between changes in price and changes in subsequent output, and further, the coefficient of elasticity of supply as the ratio of the increase in supply to the previous supply divided by the ratio of the increase in price to the previous price. The coefficients of elasticity for the three ratios were as found in Table 9.

TABLE 9.—COEFFICIENTS OF ELASTICITY OF SUPPLY<sup>1</sup> OF HOGS

|  |  |
|--|--|
| When the December corn-hog ratio lagged 9 to 15 months was—                  | The coefficient of elasticity of supply was— |
| 10 to 30% below normal.....  | .63  |
| 10% below to 10% above normal.....   | .58  |
| 10 to 30% above normal.....  | .23  |
| When the average June to November corn-hog ratio lagged 12 to 18 months was— | The coefficient of elasticity of supply was— |
| 10 to 30% below normal.....  | 1.06   |
| 10% above to 10% below normal.....   | .72  |
| 10 to 30% above normal.....  | .33  |
| When the average January to March corn-hog ratio lagged 6 to 12 months was—  | The coefficient of elasticity of supply was— |
| 10 to 30% below normal.....  | .66  |
| 10% below to 10% above normal.....   | .11  |
| 10 to 30% above normal.....  | .05  |
| When the combined corn-hog ratios lagged for 6 to 18 months were—            | The coefficient of elasticity of supply was— |
| 10 to 30% below normal.....  | .324   |
| 10% below to 10% above normal.....   | .393   |
| 10 to 30% above normal.....  | .167   |

$$^1\text{The coefficient of elasticity of supply} = \frac{\text{Percentage change in receipts}}{\text{Percentage change in corn-hog ratio}}$$

From these tables and from the tables and charts presented in the context it should be possible, assuming farmers in this section will react in the present and immediate future in the same way as they have in the past, to determine fairly accurately just about what response in production will follow given changes in these ratios, and further, by using the index of climate at farrowing time and trend as additional

factors, it should be possible under the same conditions to estimate pretty accurately about what total production will take place each year.

Of course disturbing factors will enter in from time to time which will increase the error of estimate. The pig survey recently inaugurated by the Bureau of Agricultural Economics, U. S. Department of Agriculture, may prove to be such a factor. It is very probable that as farmers come to understand the purpose and meaning of this survey they will be inclined to respond somewhat differently than they have done in the past. It will not be possible to measure just what influence this additional factor has until it has been in effect for a considerably longer period than at present. Other factors may have a similar influence or, if not the same influence, may produce results which will tend to increase the error of estimate. Such of these disturbing factors as are capable of statistical treatment, however, probably can be measured and corrected for, after a sufficient period has elapsed to make their determination possible.

#### ELASTICITY OF THE SUPPLY OF HOGS IN DIFFERENT TYPES-OF-FARMING AREAS IN ILLINOIS

Having determined the important factors responsible for the variations in receipts of hogs at Chicago from year to year, an attempt next was made to determine the elasticity of supply of hogs in different type-of-farming areas in Illinois.

To make such a study necessitated the use of county data on hog production. The data used were taken from the State Department of Agriculture Reports and covered the number of hogs on farms on May 1 in each county from 1898 to 1916. These series include both pigs farrowed in the fall and in the spring and make no distinction as to sex or age. The county data were combined into regional or area totals according to the type-of-farming map generally accepted in the state. The figures showing the variation in the number of hogs on farms on May 1 each year were assumed to indicate fairly accurately the changes in the number of hogs on farms on May 1 each year in each area and were taken as the dependent variables in each case. The method of analysis was that of multiple curvilinear correlation. Since the technique was the same as used in the preceding study, the various steps in the analyses will not be repeated here.

Designating percentage changes of hogs on farms on May 1 from year to year as the dependent variable  $X_1$  in east-central Illinois, the following independent variables, lagged as indicated, were correlated with it:

$F''X_2$  = Corn-hog ratio (December), lagged 9 to 15 months.

$F''X_3$  = Corn-hog ratio (average June to November), lagged 12 to 18 months.

$F''X_4$  = Corn-hog ratio (average January to March), lagged 6 to 12 months.

$F''X_5$  = Trend.

The index of multiple curvilinear correlation was .867.

In western Illinois the same independent variables were used except that the corn-hog ratio for June, lagged 12 to 15 months, was used instead of the average ratio for June to November. The functional values used also were read of course from the net regression line and curves showing the relationship between the various independents and hogs on farms in western Illinois. The degree of relationship is indicated by an index of multiple curvilinear correlation of .89 which was secured.

TABLE 10.—COEFFICIENTS OF ELASTICITY WITH VARIOUS CORN-HOG RATIOS

| Corn-hog ratio                  | Coefficient of elasticity <sup>1</sup> |                                     |                                      |                                  |
|---------------------------------|--|-------------------------------------|--------------------------------------|----------------------------------|
|                                 | East-Central Illinois, grain section   | Western Illinois, livestock section | Southwestern Illinois, wheat section | Northern Illinois, dairy section |
| 10 to 30% below normal.....     | .37                                    | .086                                | .097                                 | .15                              |
| 10% below normal to 10% above.. | .46                                    | .25                                 | .25                                  | .25                              |
| 10 to 30% above normal.....     | .55                                    | .37                                 | .43                                  | .20                              |

$$^1\text{Coefficient of elasticity} = \frac{\text{Percentage change in receipts}}{\text{Percentage changes in corn-hog ratio}}$$

Using percentage changes in number of hogs on farms in southwestern Illinois as the dependent variable, and correlating with the same independent variables used in the east-central Illinois study, an index of multiple curvilinear correlation of .917 was obtained.

Using percentage changes in number of hogs on farms in northern Illinois in the dairy district as the dependent variable, and correlating with the same independent variables used in the preceding determination, an index of multiple curvilinear correlation of .66 was secured.

Tables were presented in the main body of the bulletin showing the net relation between percentage changes in the corn-hog ratios (combined) and percentage changes in the number of hogs on farms in each type-of-farming area. The coefficients of elasticity were not presented, however. They were as found in Table 10.

It will be noted (Table 10) that a 10 percent change in the corn-hog ratio did not result in the same percentage change in receipts in each area, but varied widely. The coefficients of elasticity also varied widely



according to the particular level at which the ratio stood. That is to say, farmers in different sections, as well as within each section, responded differently in their production when the corn-hog ratio was high than they did when it was low. While these results bear out the hypothesis made, and conform very closely to what theoretically would be expected, the conclusions reached here are tentative until a more thoro statistical analysis can be made. The index of multiple correlation is not high enough in one or two of the sections, particularly in the dairy section, to be used with absolute confidence.













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