Research Bulletin 809 June 1958

THE DEMAND FOR HOGS

By
H. C. WILLIAMS
and
R. W. SHERMAN

OHIO AGRICULTURAL EXPERIMENT STATION
WOOSTER, OHIO

This page intentionally blank.

TABLE OF CONTENTS

LIST OF TABLES

CONCLUSIONS

Hog producers are keenly aware of the variation in hog prices from year to year. This variation is caused by changes in the factors and forces which affect both the producer and buyer sides of the market.

This study indicates that on the producer's side of the market the fall pig crop of the previous year and breeder's intentions as of December for the coming spring crop significantly affect the quantity of hogs produced for market in the current year. A one percent change in size of the fall pig crop of the previous year was associated with a .39 percent change in quantity produced. A one percent change in breeder's intentions regarding the size of coming spring pig crop was associated with a .23 percent change in the quantity produced. Corn supply and the hog-corn price ratio of the previous September to December probably have their greatest effect on the size of the fall pig crop and breeder's intentions regarding the size of coming spring pig crop.

The price-quantity relationships for hogs during the war years did not differ significantly from the non-war years. Since prices were controlled during these years the controlled prices were set at levels which would have been normally associated with the given yearly supplies.

The percentage change in quantity taken off the market was slightly greater than the percentage change in price in the opposite direction. As such hog producers in the aggregate received a slightly greater total income from increases in the number of hogs produced for market. Since any reduction in quantity produced for market would result in a lower total income to hog producers, any control which would decrease output would appear to have an unfavorable effect on gross farm income received from hogs.

It was found that a given percentage increase in disposable income in the United States would increase total income to hog producers more than the same percentage increase in price.

INTRODUCTION

One of the major management decisions of hog producers is deciding on the number to produce for market that will return the highest net income. This decision is based on expected prices and expected cost of production. Because of the nature and structure of cost of production, primarily feed, cost can be estimated more easily and with less error than expected prices. Expected prices on the other hand, are influenced primarily by forces outside management control. As such they are more difficult to estimate and subject to greater error in formulating expectations with the information that is readily available.

This study is designed to analyze those factors which affect the prices received by farmers for hogs at the farm level. As such the findings of this study could greatly aid the decision making process by providing a basis for estimating future hog prices more accurately.

This study also contributes to a basic understanding of the factors and forces responsible for year to year changes in prices received by farmers for hogs.

It further provides data which could be of use to the legislator in setting agricultural policy. For example, suppose the aim of agricultural policy with respect to hog producers were to raise farm income.

How should it be done? High support prices? Low support prices? Direct payments to producers? Control production? The answer lies in the nature of the quantity response to a change in price. Where the percentage change in quantity is greater than the percentage change in price, lower supports (if supports are mandatory) or no supports would raise income. Further where such a condition exists the total program would cost less if no supports were imposed and direct payments made to producers to make up for the difference between income derived from the market and some predetermined level of income. On the other hand, if the percentage change in quantity is less than the percentage change in price, higher supports would raise income and, at the same time, decrease the cost of such a program below the cost of direct payments in providing a given level of income.

Seasonal variation in hog prices is not considered in these analyses. While it is important to individual producers who attempt to maximize income by marketing when prices are favorable, it is not to all producers in the aggregate. Should all

producers or a large number of producers attempt to market hogs when seasonal prices are high, there would simply be a shift in the seasonal price pattern. Over the years there has been a shift in the months in which hog prices are highest. However, it is not likely that the average price for the year would be materially changed by such shifts in marketing.

The data on which this study is based include annual production of hogs, annual production of other red meats (beef, veal, lamb and mutton), storage holdings, net foreign trade, and price and income data for the years 1929 through 1951.

ECONOMIC MODEL

Economic theory and knowledge of the specific commodity characteristics permit the formulation of explicit assumptions as to the way certain observed data are produced. From these we can specify the relevant variables and the relationship assumed to exist between them.

In a static society demand is a function of price. This oversimplified statement presents a model which could be used in the estimation of demand parameters. However, when applied to a dynamic situation it is unrealistic and must be modified so as to embrace refinements, whose purpose is to either remove, or measure, the effect of various extraneous and disturbing (complicating) factors.

These complicating factors are of three general types: (1) general factors treated in theoretical economics; (2) specific factors peculiar to a given commodity in a given time period; and (3) non-economic factors (primarily sociological and psychological) which cannot be discounted in economic analyses.

Among the factors categorically placed under these types are:

(1) Disposable income

(2) Price of the specific commodity

(3) Prices of all other commodities

(4) Population

(5) Consumption habits

(6) Size and age composition of families

These variables make themselves felt over time and, at least to some extent, must be taken into consideration in order to obtain satisfactory results.

The economic model which forms the basis for the ensuing analyses is as follows:

$$P = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8)$$

where

P is price

X_1 is market supply of the specific commodity

X_2 is the quantity of other red meats

X_3 is real disposable income

X_4 is marketing margin as a percent of retail price

X_5 is prices received by farmers for all foods

X_6 is population

X_7 is consumption habits

X_8 is size and age composition of families

In the model X_1 -- X_8 are considered pre-determined or exogenous, that is, their current respective values are not influenced by the current respective values of the other variables in the same structure.

Price is taken as the dependent variable in this model because of two reasons. They are:

(1) The model is primarily designed to forcast price; and

(2) In dealing with a market aggregate rather than individual actions it is assumed that prices adjust to quantity available rather than vice versa.

With most agricultural commodities the production period precedes the marketing period, hence the supply represents a fund rather than a flow. Therefore current production is independent of current price. The market price is associated with

the "produced" commodity. Hogs and cattle are among these commodities.

The quantity variable used in these analyses is total slaughter, plus carryover from preceding year in storage, minus net foreign trade.

The question might arise, why carryover in storage from the preceding year rather than net change in storage during the current year? The former was chosen on the grounds that the quantity on hand at the beginning of the year assumes an important role in setting the level of prices for the specific commodity in the year into which it is carried. Once the level is set storage holding movements tend to equalize supply and stabilize price. The logic here is consistent with reason (2) for choice of price as the dependent variable.

POPULATION

Population is an important variable in determining the general level of demand. With an increase in population, in general, we get a shift to the right of the demand curve (with other things remaining unchanged). By including population in the model we get a refinement due to its effect. The manner of including this variable was to place all quantity and income data on per capita basis. In this way the effect of population is eliminated.

PRICES OF ALL FOODS

In general we can say that given a limited income (purchasing power) all goods compete with each other in the endeavor of maximizing total satisfaction, or any given end. However, from logic and experience it is not unreasonable to postulate that similar goods (in a physical sense) tend to more actively compete with one another than dissimilar goods. For example we can expect more active competition, in the main, between beef steaks and pork chops in maximizing satisfaction, than between beef steaks and television sets. However, it should be pointed out that in special cases, the latter is not at all beyond the realm of realism.

With the above underlying rationale an index of prices received by farmers for all foods rather than one of the general level of prices (consumer or wholesale) was chosen as the appropriate reflector of the prices of other commodities. While many would contend that the index of prices received by farmers for all foods

is more relevant to a supply function than a demand function we are not fully in accord with this contention without modifications or reservations. Admittedly this index (prices received by farmers for all foods) does reflect changes in the relative profitability among commodities and hence affect expectations and production plans. In this case it is relevant to the supply function. However, since current production is independent of current price for most food commodities its relevance must be viewed in a lagged sense.

On the other hand current prices of all foods have an effect on the prices of specific food commodities, hence the inclusion of the prices of all food will account for the changes in the price of a specific commodity due to variation in the prices of all foods in the aggregate. 1/

For these reasons it is also relevant to a demand function.

QUANTITY OF OTHER RED MEATS

It is reasonable to suppose that the quantity of all red meats affect the relative price of specific meats within the group. The extent of the effect however, is conditioned by the substitutability of the respective meats for each other. The inclusion of this variable will yield an estimate of the substitutability of all other red meats in the aggregate for the specific meat being analyzed. This estimate is an average and as such is higher than that for some of the individual meats and lower than that for others.

REAL DISPOSABLE INCOME

Disposable personal income is important in approximating the demand function. Fox states that, "the disposable income of domestic consumers has proved to be the best over all indicator of demand for agricultural products consumed by them." 2/ Disposable income is recognized as one of the more important determinants of the level of demand and is highly correlated with

---

1/ Ideally it would have been more appropriate to have used an index of prices received by farmers excluding the prices of the specific commodity being analyzed.

2/ Fox, Karl, "Factors Affecting Farm Income, Farm Prices and Food Consumption." Agricultural Economic Research, Vol. III, No. 3, July, 1951 P. 67.

total outlay for the specific commodity. Therefore it appears highly desirable to take this factor into consideration in demand analyses. Also, its inclusion will yield an estimate of the specific effect that variation in income has on the demand for a specific item.

In using disposable income a choice had to be made between money disposable income and real disposable income. The latter was chosen on the grounds that it more accurately reflects true variations in income and consequently more accurately reflects the true effect of variation in income on demand. In these analyses the purchasing power of each unit of disposable income is held constant and the effect of changes in the number of these units is measured.

Stone treats the problem of the choice between these two and concludes that both should yield similar though not identical results. 1/

Not only is the aggregate real disposable income important but also its distribution. There is a fund of a priori information which suggests that the response to changes in income is affected appreciably by the level of income prior to the change. However, to treat this problem it is necessary to work with family budget data. It is most difficult to effectively treat this problem when working with time series data.

Then too because of the nature and level of demand for which these analyses are designed to treat the aggregate real disposable income is perhaps the more appropriate variable.

CONSUMPTION HABITS

Consumption habits constitute a non-quantitative variable which affects the price-quantity relationships for specific commodities over time. Its manifestation can result in a shift in the demand curve, with other things remaining unchanged. Because of its recognized influence and non-quantitative characteristic it has been treated in several ways. Moore and Henry Schultz assumed that demand behavior of human beings is routine and consequently no significant changes occurred during the time

---

1/Stone, Richard, "The Analysis of Market Demand, "Royal Statistical Society Journal, 108: P. 291

period considered. 1/ Others have used time as a "catch all" variable to explain this source of variation and other sources not explicitly introduced.

In our analyses time is included as a sort of catch all variable to explain variation in price due to variation in consumption habits, size and age composition of families and other variables not explicitly introduced.

Time only makes it possible for appropriate variables to make themselves felt. If it were possible to specify all of these variables (quantitative and non-quantitative) which are included in the catch-all "time" there would be no other effect of time.

The introduction of time as a catch all variable recognizes the presence of residual trend and as such attempts to estimate its value.

The included analyses were designed to approximate the demand function at the farm level. Hence the farm price is related to the factors shown in the economic model. While most of the assumed independent factors relate to the retail level specifically, it is not inconsistent to employ them when dealing with the farm level. For under the maximization assumption it is not unreasonable to suppose that over time, the derived demand at the farm level accurately reflects consumer demand. In the words of Marshall, "The ultimate regulator of all demand is ..... Consumer's demand." 2/

The time period on which these analyses are based is 1929-51. Many economists and statisticians leave out the war years, feeling that war time controls, rationing, armament expenditures, etc., seriously affected the price-quantity relationships and have derived relationships based on the inter-war period. It was felt that the inclusion of the war years and the years immediately following the cessation of hostilities could add much to demand analyses. It is only during such periods that wide enough swings occur in some factors considered exogenous to give reliable estimates of their influences. Then too, when these years are removed the derived functional relationship is far enough removed, in time, as to seriously affect its applicability.

2/Schultz, Henry. "Theory of Measurement of Demand." Chicago, University of Chicago Press, 1938, P. 65.

1/Marshall, Alfred, "Principles of Economics." 8th Edition, MacMillan & Co. Ltd. London, 1930, P. 92.

To get an indication of the war year effects "dummy variables" corresponding to the assumed fixed variables were included in the model. Each of these dummy variables was given a value of zero in the non-war years and the value of the fixed variable in the war years.

STATISTICAL SPECIFICATION

Though theory enables us to specify the relevant variables, their probable signs and relative magnitudes, it does not tell us how they are related. It is left to the researcher to specify the relationship assumed to exist, which might be either additive, multiplicative, or reciprocative.

In the choice of the appropriate mathematical function certain a priori assumptions are involved. If a linear function is chosen using natural units of the data it is assumed that the elasticity will vary throughout the range. If a linear function using logarithms of the data is chosen it is assumed that the elasticity is constant along the curve. Which of the two assumptions is more appropriate? Perhaps neither is clearly a preferable choice the other in all cases. Foote and Fox state that where the relationship is believed to be either multiplicative, or more stable in percentage terms or both, the logarithmic function should be chosen; that a function using arithmetic variables should be used where the relationship is believed to be additive. They conclude that only in a few special cases can the choice of mathematical functions be determined from the data before they are analyzed. 1/

In the past the logarithmic function has been used largely because of its convenience. Also because it has the practical advantage of yielding coefficients that are in themselves elasticities, terms in which economists usually think, and further that these elasticities are constants.

It cannot be unequivocally stated that quantity responses to price changes are constant at all levels of price, or whether the response is relatively greater at high prices than at low prices. There is a fund of a priori knowledge which leads one to a negation of the constant elasticity concept and to suspect that for most food items the elasticity is lower when available quantities are large and prices low than when the opposite situation prevails.

1/Foote, R. J. and Fox, Karl, Analytical Tools for Measuring Demand Ag. Hdbk. No. 64 U. S. D. A., Jan. 1954, P. 9 & 10.

Because of the inability to clearly predetermine the most appropriate mathematical function it is therefore desirable to employ several statistical specifications of the economic model presented and compare the results. The criteria for comparison will consist of (1) the standard error of estimated structural parameters, (2) explained variance; and (3) an application of each of the specifications to predict prices for the years 1952, 1953, and 1954.

The statistical specifications include:

(1) The additive form fitting an equation linear in actual values. An example is:

$$P = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 t$$

Where X_1 is per capita market supply, X_2 per capita quantity of other red meats, X_3 per capita real disposable income and t time (with 1928 base). The observed market price is deflated by the index of price received by farmers for all foods. Hence P is the quotient of the ratio of market price to index of prices received by farmers for food.

The equation is fitted to the data covering the period 1929-51.

This equation permits the determination of elasticity coefficents for various segments of the curve. Consequently it will test the hypothesis that elasticity is not constant for the derived demand function.

(2) The multiplicative form fitting an equation linear in logarithms of the actual values. An example is:

$$P = a X_1^{b1} X_2^{b2} X_3^{b3} e^{ct}$$

Where X_1 is per capita supply of hogs, X_2 per capita supply of other meats, X_3 real per capita disposable income, t time, and e base in natural logarithms.

The equation is fitted in logarithmic form to date covering the same period, 1929 - 1951. This equation form yields elasticities which are constants.

(3) Deflation analysis using arithmetic values assuming a curvilinear relationship.

$$P = a + bX + c_{x2}$$

In this function the price-quantity relationship is reduced to two variables price and quantity. The procedures involved are as follows:

The quantity of hogs is placed on a per capita basis. The observed price is divided by the index of prices received by farmers for all food and by the index of real per capita disposable income.

These adjustments were made to remove the effect of these extraneous factors. To the extent that a one to one relationship exists between the variable being deflated and the deflator the results should closely approximate those obtained from the multiple regression technique.

This specification was included because of its relative simplicity and to make a comparison of its derived results with those based on multiple regression. It should be pointed out that this model, based on deflation, can be used only for prediction. Because of this fact the multiple regression technique has decided advantages over deflation in the sense that it permits estimation of parameters, as well as providing a predictive index. These parameters can be tested for statistical significance. It is therefore possible to determine the effect, in a statistical sense, that each variable has on the derived relationship. Where the researcher is interested in describing market demand, when there has been no change in structure multiple regression is a most useful tool.

SUPPLY OF HOGS

The total market supply of hogs exhibits considerable year to year variation over the period covered by these analyses. This variation is by no means uniform. In terms of total pounds, the supply varied from a low of 11.3 billion pounds in 1935 to a high of 22.4 billion pounds in 1943, a change of almost 100 percent from the low to the high.

When total supply is analyzed in terms of successive five year periods beginning in 1929 a trend allied with that of the business cycle is indicated. (See Table 1) There was a decrease in the total supply from the first to the second period. A contributing and perhaps primary factor for the lower supply during the period 1934-38 was governmental manipulation of supply. During the year, 1933 under the emergency hog production program, in late summer and early fall, 6.4 million pigs and sows were purchased

for governmental account. Concomitant with this, yearly production decreased until 1935 when a trough position was reached.

Table 1. TOTAL SUPPLY OF HOGS BY PERIODS AND THE AVERAGE YEARLY SUPPLY FOR EACH PERIOD, UNITED STATES, 1929-51

(In billion pounds liveweight)

PERIOD	TOTAL SUPPLY	AVERAGE YEARLY SUPPLY
1929-1933	79.1	15.82
1934-1938	67.3	13.46
1939-1943	92.6	18.52
1944-1948	95.6	19.12
1949-1951	58.3	19.33

With this variation in production what happened to the relationship between population and supply? During the period population increased throughout, however, there were changes in the rate of increase. When supply is placed on a per capita basis the pattern shown in Table 1 is modified. (See Table 2) Even though there is an increase in the average yearly supply for each period following 1933-1938, the average annual per capita supply reached a high in the period 1939-1943 and declined successively thereafter. This indicates that for these latter periods population increases were relatively greater than those in supply.

Table 2. PER CAPITA SUPPLY OF HOGGS BY PERIODS, AND THE AVERAGE YEARLY PER CAPITA SUPPLY FOR EACH PERIOD, UNITED STATES, 1929-1951.

(In pounds)

PERIOD	PER CAPITA SUPPLY	AVERAGE ANNUAL PER CAPITA SUPPLY
1929-1933	639	127.8
1934-1938	526	105.2
1939-1943	693	138.6
1944-1948	675	135.0
1949-1951	384	128.0

Why were there such variations in market supply as noted above? To answer this question it is necessary to consider the

components of the aggregate quantity variable termed" market supply". This veriable includes (1) production (total pounds slaughtered), (2) carryover in storage, and (3) net foreign trade.

(1) Production (pounds slaughtered) in any given year is a direct function of the number of hogs slaughtered times average weight at slaughter. However, the number produced for slaughter is determined primarily by current spring pig crop and fall pig crops the previous year. These in turn are dependent upon the cycle, expectations and quantity of available feed.

In the statistical derivation of a supply function for hogs, breeders intentions as of December regarding the following spring pig crop is substituted for current spring crop. 1/ The hog-corn price ratio the previous September-December is taken to reflect expectations regarding price. Fitting a logarithmic function for the period 1924-1951 expressing total production as a function of

X_1--Spring pig crop previous year

X_2--Fall pig crop previous year

X_3--Breeder's intention regarding current spring pig crop

X_4--Corn Supply previous year

X_5--Hog-corn price ratio previous September-December

The following results were obtained:

$$Y = .9699 + .1741X_1 + .3886X_2 + .2334X_3 + .0592X_4 + .0162X_5$$
$$(-- \quad (.1230) \quad (.0674) \quad (.0921) \quad (.0729) \quad (.0586)$$

(The figures in parantheses are standard errors of the regression coefficients). $R^2 = .957$ $Sy = 10.3\%$

This analysis indicates that more than 95 percent of the calendar year variation in total production is explained by these factors. Fall pig crop of the previous year and breeders

---

1/This does not appreciably alter the results. Breeders intentions regarding spring pig crop and the actual spring pig crop are positively correlated (.92). Then too, since the size of the actual spring crop is not known until it is produced it is expedient to get an accurate indication of its size incorporated into the model for predictive purposes.

intentions regarding current spring pig crop were significant, with the former being highly significant. Corn supply previous year and hog-corn price ratio previous September-December do not significantly affect current production (5% level). This is probably explained by the fact that these two factors are correlated with the other factors included. Spring pig crop previous year does not significantly affect total production. This is probably explained by the fact that marketable hogs are marketed during the previous year and those held for breeding purposes are reflected in breeders intentions regarding the current spring crop.

(2) Carryover in storage represents a relatively small proportion of market supply, however, it serves as a cushion for the domestic market. That is, it eases the shock, or minimizes fluctuations in price by tempering the magnitude of the changes in market supply due to changes in production. This is indicated by the general direct relationship between production in the previous year and carryover into the current year; and the indirect relationship between price in the previous year and carryover.

(3) Net foreign trade also serves as a cushion for the domestic market. The resultant effect of exports is the intersection of the demand and supply curves at a point farther to the left than would have otherwise occurred. As with carryover in storage, exports are positively correlated with production. In spite of the positive correlation between production and exports there is an apparent decreasing trend in the proportion of the total crop exported.

Imports of pork and pork products represent a very small proportion of domestic market supply. These imports are differentiated from domestically produced pork and perhaps do not seriously compete with domestically produced pork as pork in the diet but rather as a meat in total meat consumption. However for convenience, imports are subtracted from exports to obtain net foreign trade.

To obtain the quantity variable termed market supply, liveweight equivalent of cold storage holdings at the beginning of the year plus production during the year minus net foreign trade were aggregated.

THE DEMAND FOR HOGS

As pointed out earlier, it was impossible to determine the most appropriate mathematical function to use in the approximation

of the demand function on a priori reasoning. Therefore several statistical specifications of the economic model were employed.

One of these, using the additive form, fitting a function linear in actual values, yielded the following results:

$$(2.1)\ \hat{Y} = 8.068 - .05627\ X_1 + .01538\ X_2 + .04151\ X_3 - .0523\ X6$$
$$(.0136)^{**}\underline{1}/\quad (.015)\qquad (.0162)^{*}\qquad (.0561)$$

$R^2 = .68$ $\quad Sy = \$0.82$

(Figures in parentheses are standard errors)

Where:

X_1, is per capita hog supply

X_2, is per capita supply other red meats

X_3, is index of real per capita disposable income

X_6, time, with origin 1928

Approximately 68% of the variation in the price of hogs per hundred pounds is accounted for by the included explanatory variables.

The function shows an inverse relationship between quantity of hogs and price and a direct relationship between price and real per capita disposable income. These are as might be expected from economic theory and/or a priori grounds.

The b value for per/capita supply of other red meats though expected to be significant is not significantly different from zero (5% level). This is in accord with the findings of Fox. 2/ The sign of the b value though expected to be negative is positive which would indicate, if the b value had been significant, that other red meats as a group are completing in demand.

The b value for the time variable is also nonsignificant. This

---

1/ In these analyses
* Indicates b values significant at 5 per cent level.
** Indicates b values significant at 1 per cent level.

2/ Fox, Karl, "The Analysis of Demand for Farm Products." U. S. Dept. Agr. Tech. Bull. 1081 P. 44.

variable was included to get an estimate of the effect that variables not explicitly introduced into the analysis, and yet systematically correlated with time, have on the price of hogs.

Table 3. COMPARISON OF ACTUAL PRICE AND PRICE ESTIMATED FROM EQUATION (2.1)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.54	108
1951	7.49	7.63	102
1952	7.04	8.00	114
1953	9.07	9.81	108
1954	9.69	10.03	104

This function overestimates price for each of the years 1950-54 inclusive. The overestimation ranged from 2 percent to 14 percent with an average of 7.2.

Next, to get an indication of the war year effects on the relationship a function was devised employing dummy variables in addition to the variables in (2.1). Using the additive form, fitting a function linear in actual values, the following results were obtained:

$$(2.2)\quad \hat{Y} = 7.38 - .0746\,X_1 + .0299\,X_2 + .0546\,X_3 - .0964\,X_6$$

$$(.0119)^{**} \quad (.0134)^{*} \quad (.0132)^{**} \quad (.0491)$$

$$+ .0855\,X_a + .0212\,X_b - .1046\,X_c$$

$$(.0269) \quad (.0666) \quad (.0903)$$

$R^2 = .86$ $\quad$ $Sy = .57$

Where X_1, X_2, X_3, X_6 are the same as in equation (2.1) and

$X_a = X_1$ in war years; 0 in non-war years

$X_b = X_2$ in war years; 0 in non-war years

$X_c = X_3$ in war years; 0 in non-war years

The results indicate that when dummy variables are included to measure the effect of war years the proportion of explained variation increased to 86 percent, an increase of slightly more than 25 percent.

As with function (2.1) there is an inverse relationship between quantity and price and a direct relationship between price and real per capita disposable income.

The b values for per capita hog supply and real per capita disposable income are significant at the one percent level, while that for per capita supply of other red meats is significant at the 5 percent level.

The b value for the variable included to measure the war time effect of the quantity of hogs is significant at the one percent level. However since prices during this period were controlled and only supply was variable we may infer that the controlled prices were set at levels which would have normally been associated with the given yearly supplies. Hence the price quantity relationship for the war years did not differ appreciably from the non-war years.

The b values for the variables included to measure the war year effects of the other variables were not significant at the 5 percent level.

We may conclude from this that the relationship between these fixed variates and the price of hogs in the war years were not significantly different from the non-war years.

Table 4. COMPARISON OF ACTUAL PRICE AND PRICE ESTIMATED FROM EQUATION (2.2)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.44	107
1951	7.49	7.35	98
1952	7.04	7.93	113
1953	9.07	10.66	117
1954	9.69	10.94	113

For predictive purposes this function gives larger errors than (2.1). It overestimates price in each year except 1951. Estimated

prices range from 2 percent below the actual market price to 17 above with an average error of 10.4 percent. The poorer predictive results is probably attributed to the fact that the war effects have been removed from each of the estimated parameters and because of the manner of their removal they are not included in the estimating equation.

Employing the multiplicative form and fitting a linear function in logarithms of the actual values the following results were obtained:

$$(2.3)\quad \text{Log } \hat{Y} = .8409 - .9943 \log X_1 + .2159 \log X_2 + .8235 \log X_3 - .0100 \log X_6$$

$$(.1912)^{**} \qquad (.2639) \qquad (.2053)^{**} \qquad (.0064)$$

$R^2 = .77 \qquad Sy = 11.3\%$

Where:

X_1, is per capita supply of hogs

X_2, is per capita supply of other meats

X_3, real per capita disposable income

X_6, time ($t \log_{10} e$, origin 1928)

Seventy-seven percent of the calendar year variation in the variation in the price of hogs is explained by the factors included.

The signs of the coefficients indicate an inverse relationship between the quantity of hogs and price; and a direct relationship between income and price. This is as expected from theory.

Again, as with the linear function in natural units of the data, per capita supply of other red meats is a non-significant variable.

The function indicates that a one percent increase in the market supply of hogs decreases the price of hogs .994 percent (not significantly different from unity); a one percent increase in real per capita disposable income increases price by .824 percent.

Table 5. COMPARISON OF ACTUAL PRICE AND PRICE ESTIMATED FROM EQUATION (2.3)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.29	105
1951	7.49	7.57	101
1952	7.04	7.88	112
1953	9.07	9.84	108
1954	9.69	10.16	105

This function overestimates the actual market in each year. For estimating purposes it is better than functions (2.1) and (2.2). The range of error in estimating is from one to 12 percent with an average error of 6.2 percent.

Since the per capita supply of other red meats (X_2) was non-significant it was dropped from the analysis and the following results obtained:

$$(2.4)\quad \log \hat{Y} = 1.189 - 1.016 \log X_1 + .9014 \log X_3 - .0097 \log X_6$$

$$(.1876)^{**} \qquad (.1802)^{**} \qquad (.0064)$$

$R^2 = .76 \qquad Sy = 11.2\%$

This function indicates that a one percent increase in per capita hog supply is associated with a 1.02 percent decrease in price. A one percent change in real per capita disposable income is associated with a 0.9 percent change in price in the same direction.

With respect to total revenue, any increase in output will result in slightly less total returns to farmers. This indicates that if cost and revenue curves of the firm are constant, and marketing charges remain relatively constant, producers of hogs in the aggregate will receive a slightly smaller net return for any increase in output.

A comparison of price and income elasticity coefficients 1/ indicates that a given percent increase in real per capita

1/ Reciprocal of price flexibility coeffiecients $\left(\frac{1}{bi}\right)$

disposable income will increase farm income more than the same percent increase in hog prices at the farm level.

Table 6. COMPARISON OF ACTUAL PRICE AND ESTIMATED PRICE FROM EQUATION (2.4)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.47	107
1951	7.49	7.91	106
1952	7.04	8.07	115
1953	9.07	9.66	107
1954	9.69	9.93	102

This

This function overestimates the actual market price in each year. The range of the overestimation range from 2 to 15 percent with an average error by 7.4 percent for the five year period.

As pointed out earlier a function of this type reduces the price-quantity relationship to two variables by removing the effects of changes in prices received by farmers for all foods, changes in real per capits disposable income and changes in population through deflation. Fitting such a function in quadratic form yielded the following results:

$$(2.5)\ \hat{Y} = 27.37 - .2647\, X_1 + .0008\, X_1^2$$

$$(.0902)^* \qquad (.0004)^*$$

$$R^2 = .73 \qquad Sy = .74$$

Seventy-three percent of the total variation in the adjusted price is explained by variation in quantity of per capita domestic market supply of hogs. This value is somewhat higher than that obtained from the multiple regression technique employing actual values of the data (2.1). However it is somewhat lower than the value when a logarithmic function is derived using multiple regression. Both of the b values are significantly different from zero at the 5 percent level.

Table 7. COMPARISON OF ACTUAL PRICE AND PRICE ESTIMATED FROM EQUATION (2.5)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	5.16	6.26	121
1951	4.93	5.85	119
1952	4.54	5.97	131
1953	5.67	7.32	129
1954	6.09	7.76	127

This function overestimates the actual market price in each year. While the range of error is relatively small, from 19 percent to 31 percent, the error in each year is relatively high. The smallest error is slightly less than one-fifth of the actual market price and the largest slightly less than one-third. The size of the errors would tend to refute the hypothesis upon which the analyses were based, i.e. a one to one relationship between the variable to be deflated and the deflator.

In the foregoing analyses no attempt has been made to include the market effect on the price-quantity relationship for hogs. Changes in market structure and/or marketing margins, on a priori grounds can affect this relationship. It is a well known fact that marketing margins are rather rigid in nature. However when changes do occur they are either shifted forward to consumers or backward to producers. Since, in the main, we have a buyer's market for agricultural products at retail positive changes generally are reflected backward to producers.

In a similar manner when there are changes in consumer tastes the price effect is reflected back to producers. This again can be attributed to the short-run inflexibility of marketing charges.

Therefore in deriving structural parameters for the price-quantity relationships for hogs it is advantageous to include the market effect. The marketing margin as a percent of the retail price is taken as the variate which reflects this effect.

What happens when the market effect is included?

Using the additive form fitting a function linear in actual

values the following results were obtained:

$$(2.6)\quad \hat{Y} = 16.96 - .0386\,X_1 - .0125\,X_2 + .0092\,X_3 - .0889\,X_4 - .0011\,X_6$$

$$(.0153)^* \quad (.0189) \quad (.0223) \quad (.0440)^* \quad (.0555)$$

$R^2 = .75 \qquad Sy = .75$

Where:

X_1 = Per capita hog supply

X_2 = Per capita supply of other meats

X_3 = Index of real per capita disposable income

X_4 = Marketing margin as a percent of retail price.

X_6 = time, with origin 1928.

Seventy-five percent of the variation in the price of hogs is explained by the included explanatory variables.

The function shows an inverse relationship between quantity of hogs and price, and a direct relationship between price and income.

The b value for per capita supply of other red meats though expected to be significantly different from zero is not. However the direction of the effect of this variable is as expected. This sign would indicate a competing relationship with hogs.

The b value for marketing margin as a percent of retail price is significant at the 5 percent level. The sign, as expected, indicates an inverse relationship.

Table 8. COMPARISON OF ACTUAL PRICE AND PRICE ESTIMATED FROM EQUATION (2.6)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.09	103
1951	7.49	7.98	107
1952	7.04	7.76	110
1953	9.07	8.51	94
1954	9.69	8.49	88

This function overestimates price for each of the years 1950 through 1952 and underestimates the price for 1953 and 1954. The range of the error is from 3 to 12 percent with an average error of 7.6 percent.

Employing the multiplicative form fitting a function linear in logarithms the following results obtained:

$$(2.7)\quad \log \hat{Y} = 1.596 - .9592 \log X_1 + .0164 \log X_2 + .7261 \log X_3 - .1281 \log X_4 - .0081 \log X_6$$

$$(.2093)^{**} \qquad (.4478) \qquad (.3077)^{*} \qquad (.2667) \qquad (.0073)$$

$R^2 = .78$ $\quad Sy = 11.4\%$

Where:

X_1 is per capita supply of hogs

X_2, per capita supply of other meats

X_3, index of real per capita disposable income

X_4, marketing margin as a percent of retail price

X_6, time, with origin 1928.

Seventy-eight percent of the variation in the price of hogs at the farm level is accounted for by the explanatory variables.

The b value for per capita supply of hogs is significant at the one percent level and that for per capita income is significant at the 5 percent level. As expected, high prices are predicted for years of low production and high incomes.

A one percent increase in the per capita supply of hogs results in a .96 percent decrease in the price indicating a price elasticity slightly greater than unity.

Table 9. COMPARISON OF ACTUAL PRICE AND ESTIMATED PRICE FROM EQUATION (2.7)

(In 1935-1939 Dollars)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	7.89	8.28	105
1951	7.49	7.75	103
1952	7.04	7.85	112
1953	9.07	9.44	104
1954	9.69	9.68	100

For predictive purposes this function yields reasonable results. It overestimates the actual market price in each of the years 1950 through 1953 and almost exactly estimates the price for 1954. This function gives an average error of 4.8 percent in predicting prices for the five year period.

In the foregoing analyses the index of prices received by farmers for all foods was used to deflate hog prices. As pointed out earlier this was done to remove the effect of variation in other food prices at the farm level from hog prices. In this adjustment a one to one relationship was assumed. What happens when this assumption is relaxed and the prices received by farmers for all foods is brought in as a fixed variate rather than as a deflator?

Using the multiplicative form fitting a function linear in logarithms the following results were obtained:

$$(2.8)\quad \log \hat{Y} = (9.048-10) - .9297 \log X_1 + .2258 \log X_2$$

$$(.2163)^{**} \qquad (.5348)$$

$$+ .6225 \log X_3 - .0430 \log X_4 + 1.104 \log X_5 - .0107 X_6$$

(.2933) (.2933) (.1434)** (.0083)

$R^2 = .98$ Sy = 11.6%

Where:

X_1 = per capita hog supply

X_2 = per capita supply of other red meats

X_3 = index of real per capita disposable income

X_4 = marketing charges as a percent of retail price

X_5 = index of prices received by farmers for food

X_6 = time (base 1928)

The b values for per capita hog supply and prices received by farmers for food are highly significant. The b value for per capita disposable income is significant at the 10 percent level. As expected, high prices are predicted for years when supplies are low and income high.

The b values indicate that the net effect of a one percent change in supply result in a .93 percent change in the opposite direction in price (a price elasticity slightly greater than unity); a one percent change in prices received by farmers for all foods and real per capita income in the United States results in a 1.1 and .6 percent change in price, respectively. 98 percent of the variation in price is explained by the fixed variates.

Table 10. COMPARISON OF ACTUAL PRICE AND ESTIMATED PRICE FROM EQUATION (2.8)

Year	Actual market price	Estimated market price	Percent that estimated is of actual
1950	18.00	21.70	121
1951	20.00	21.81	109
1952	17.80	21.81	123
1953	21.40	22.11	103
1954	21.60	22.01	102

For each year the predicted price is greater than the actual market price. In two years it is greater by more than 20 percent. In two years it is less than 4 percent greater. The average error for the 5 year period is 11.6 percent.

From each of the preceding equations it was possible to estimate the annual average price received by farmers. These equations gave various degrees of accuracy in estimating yearly prices for the five year period 1950 through 1954. The average error in estimating yearly market prices for the five year period ranged from 4.8 to 25.4 percent. These results are summarized in Table 11.

Table 11. AVERAGE ERROR AND RANGE OF ERROR FOR ESTIMATING EQUATIONS

Equation Number	Form of Equation	Independent Variables 1/	Average error	Range of error
			(percent)	(percent)
(2.1)	arithmetic	X_1, X_2, X_3, X_6	7.2	2 to 14
(2.2)	arithmetic	X_1, X_2, X_3, X_6 X_a, X_b, X_c	10.4	-2 to 17
(2.3)	logarithmic	X_1, X_2, X_3, X_6	6.2	1 to 12
(2.4)	logarithmic	X_1, X_3, X_6	7.4	2 to 15
(2.5)	arithmetic	X_1, X_1^2	25.4	19 to 31
(2.6)	arithmetic	X_1, X_2, X_3, X_4, X_6	7.6	-12 to 10
(2.7)	logarithmic	X_1, X_2, X_3, X_4, X_6	4.8	0 to 12
(2.8)	logarithmic	X_1, X_2, X_3, X_4, X_5, X_6	11.6	2 to 23

1/ X_1 is per capita hog supply
X_2 is per capita supply of other red meats

X_3 is real per capita disposable income.
X_4 is marketing margin as a percent of retail price
X_5 is index of prices received by farmers for food
X_6 is time with base 1928
X_a is equal to X_1 in war years; 0 in non-war years.
X_b is equal to X_2 in war years; 0 in non-war years.
X_c is equal to X_3 in war years; 0 in non-war years.

Estimates of the net effect of a one percent change in per capita market supply of hogs ranged from -.65 percent to -1.25 percent with five of the seven price flexibility coefficients ranging between -.93 percent and -1.02 percent (Table 12). In terms of elasticity of demand with respect to price, these coefficients ranged from -1.53 for equation (2.6) to -.80 for equation (2.2). Five of the seven elasticity coefficients ranged from -.98 to -1.1.

Table 12. SUMMARY OF ESTIMATING EQUATIONS

Equation Number	Form of Equation	Independent Variables 1/	EFFECT ON PRICE OF A ONE PERCENT CHANGE IN	
			Per Capita Market Supply	Disposable Income
(2.1)	arithmetic	X_1, X_2, X_3, X_6	- .94	.71
(2.2)	arithmetic	X_1, X_2, X_3, X_6 X_a, X_b, X_c	-1.25	.88
(2.3)	logarithmic	X_1, X_2, X_3, X_4	- .99	.82
(2.4)	logarithmic	X_1, X_3, X_6	-1.02	.90
(2.6)	arithmetic	X_1, X_2, X_3, X_4 X_6	- .65	.15
(2.7)	logarithmic	X_1, X_2, X_3, X_4 X_6	- .96	.72
(2.8)	logarithmic	X_1, X_2, X_3, X_4 X_5, X_6	- .93	.62

1/ For definitions of independent variables see footnote of preceeding table (Table 11).

The coefficients indicating the net effect of a one percent change in disposable income in the United States range from .15 percent in equation (2.6) to .90 percent in equation (2.4).

As exhibited above, these equations differ in estimating the net effect of per capita market supply and disposable income on price and in the accuracy in estimating price. Which of these equations is to be taken as the most appropriate one in estimating prices?

There are several reasons for choosing equation (2.7) to estimate the annual average price received by farmers for hogs. In equation (2.7) the net regression coefficient relating market supply of hogs to prices was highly significant (one percent level) and that relating disposable income to price was significant (5 percent level). Equation (2.7) gave lower errors in estimating prices for the five year period 1950 through 1954. In one of these years (1954) there was no error in estimating average annual price and in four of the years the error in estimating price was five percent or less. For the year 1952, when the error in estimating prices was highest for all functions except (2.2), equation (2.7) gave an error less than that for six of the eight equations. Equation (2.7) gave equally good estimates for pre-World War II and for post war years, and can, therefore, be used with greater confidence.

We may therefore conclude that a one percent change in per capita market supply is associated with a .96 percent change in the opposite direction in price. In terms of elasticity of demand with respect to price a one percent change in price is associated with a 1.04 percent change in the opposite direction in per capita market supply.

With respect to disposable income a one percent change is associated with a .73 percent change in the same direction.

With respect to total revenue, any increase in output will result in slightly greater total returns to farmers in the aggregate. This indicates that if cost and revenue curves of the firm are constant, and marketing charges remain relatively constant, producers of hogs in the aggregate will receive a slightly greater net return for any increase in output.

A comparison of price and income elasticity coefficients indicates that a given percent increase in real per capita disposable income will increase farm income more than the same percent increase in hog prices at the farm level (providing marketing

charges and cost and revenue curves of the firm remain constant). This indicates that if the alternatives of raising hog prices or raising disposable income were available to the maker of agricultural policy, with respect to hogs, a smaller change in disposable income than in price would be necessary to raise farm income to a given level.

While the regression coefficient relating marketing margin as a percent of retail price is not statistically significant it is encouraging to note that the sign is as expected.