AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the
United States Department of Agriculture and Cooperating Agencies

Volume VIII | APRIL 1956 | Number 2

How Research Results Can Be Used To Analyze Alternative Governmental Policies

By Richard J. Foote and Hyman Weingarten

Since 1952, several technical bulletins [1] that deal with the demand and price structure for grains have been published by the United States Department of Agriculture. Research results from three of these bulletins can be used in an integrated way to consider possible effects of alternative governmental price-support policies for wheat and corn. This article discusses the ways in which such analyses can be made, with emphasis on the effects of alternative assumptions on the conclusions reached. It demonstrates the power of the modern structural approach for studies of this sort. Results obtained and conclusions reached in this article come directly from the application of certain systems of economic relationships based on specified assumptions. Although it is believed that these results and conclusions throw light on the alternative policies analyzed, they in no sense represent official findings of the United States Department of Agriculture. They are presented primarily to illustrate the kinds of analyses that can be made from an approach of this sort.

TWO SETS of statistical analyses are basic for the studies reported in this article, and these are supplemented by certain other analyses. The first set of analyses is an equation that shows the effect of certain factors on the price of corn from November through May, when marketings are heaviest. The other set is a system of 6 equations that shows the simultaneous effect of 14 given variables on domestic and world prices for wheat and on domestic utilization for food, feed, export, and storage of wheat for the July to June marketing year. The supplemental analyses include studies of (1) normal seasonal variation in prices and (2) relationships among prices at local and specified terminal markets. These are mentioned in later sections.

The analysis for corn is described in detail on pages 5 to 12 of Technical Bulletin 1070. It was based on data for the years 1921–42 and 1946–50. The following variables were used:

X_0—price per bushel received by farmers for corn, average for November to May, cents.

X_1—total supply of feed concentrates for the year beginning in October, million tons.

X_2—grain-consuming animal units fed on farms during the year beginning in October, millions.

X_3—price received by farmers for livestock and livestock products, index numbers (1910–14=100), average for November to May.

The following regression equation applies:

$$\text{Log } X'_0 = -0.95 - 1.82 \log X_1 + 1.71 \log X_2 + 1.36 \log X_3 \qquad (1)$$

[1] FOOTE, RICHARD J., KLEIN, JOHN W., AND CLOUGH, MALCOLM, THE DEMAND AND PRICE STRUCTURE FOR CORN AND TOTAL FEED CONCENTRATES, U. S. Dept. Agr. Tech. Bul. 1061, 1952. FOOTE, RICHARD J., STATISTICAL ANALYSES RELATING TO THE FEED-LIVESTOCK ECONOMY, U. S. Dept. Agr. Tech. Bul. 1070, 1953. MEINKEN, KENNETH W., THE DEMAND AND PRICE STRUCTURE FOR OATS, BARLEY, AND SORGHUM GRAINS, U. S. Dept. Agr. Tech. Bul. 1080, 1953. MEINKEN, KENNETH W., THE DEMAND AND PRICE STRUCTURE FOR WHEAT, U. S. Dept. Agr. Tech. Bul. 1136, 1955.

For any given year, if expected values for X_2 and X_3 are inserted, this equation can be written in the following way:

$$\text{Log } X'_0 = \log A_1 - 1.82 \log X_1 \qquad (1.1)$$

where $\log A_1 = -0.95 + 1.71 \log X_2 + 1.36 \log X_3$ for that year. In the rest of this paper, the form shown by (1.1) is used. The reader should remember, however, that the applicable value for $\log A_1$ must be obtained from equation (1).

The analysis for prices of corn makes no direct allowance for the effect of a price-support program. It is primarily of value in indicating prices that would be expected under free-market conditions if given supplies of feed concentrates were available. If prices under a support program are expected to be higher than those indicated by the analysis, the analysis suggests that part of the supply will need to be held off the market under the program, although it does not indicate directly how much must be removed.

The system of equations for wheat is described in detail on pages 36 to 50 of Technical Bulletin 1136. The analysis was based on data for the years 1921–29 and 1931–38. These are years for which direct price-support activities of the Government are believed to have had only minor effects on prices and utilization. The system can be used, however, to indicate probable effects on utilization of various types of price-support programs. Because of space limitations, a list of all variables taken as given for this system of equations cannot be included here. The list contains such items as supply of wheat, consumer income, freight rates, numbers of poultry on farms, and other variables that are believed to be affected only slightly, if at all, by economic factors not specified in the system of equations used to explain prices and utilization of wheat during a given marketing year. Included among these given variables is the price of corn, but, as is shown later, the system can be modified to include corn prices among the variables that are simultaneously determined within the system.

Variables that are assumed to be determined simultaneously within the original system of equations for wheat include the following—the symbolic letters are basically the same as those in Technical Bulletin 1136:

P_w—wholesale price per bushel of wheat at Liverpool, England, converted to United States currency, cents.

P_d—wholesale price per bushel of No. 2 Hard Winter wheat at Kansas City, cents.

C_f—domestic use of wheat for feed, million bushels.

C_e—domestic net exports of wheat and flour on a wheat equivalent basis, million bushels.

C_s—domestic end-of-year stocks of wheat, million bushels.

C_h—domestic use of wheat and wheat products for food by civilians on a wheat equivalent basis, million bushels.

All variables relate to a marketing year beginning in July. C_s is assumed to apply to stocks held in commercial hands. When a price-support program is in effect, end-of-year stocks under loan or held by the Commodity Credit Corporation are computed as a residual.

P_w is assumed to depend directly on certain given variables, hence its value in any year can be obtained by a direct solution of a single equation similar to equation (1) for corn. It then can be treated as though it were given. The values of the given variables and the calculated value of P_w for any year can be substituted in each equation. By making computations similar to those used in obtaining $\log A_1$, new constant terms can be obtained for each equation. The equations then can be written conveniently in the following form. These equations bear the same relation to the original equations as equation (1.1) does to (1).

$$C_h + C_f + C_e + C_s = A_2 \qquad (2)$$
$$C_h + 0.0015LP_d = LA_3 \qquad (3)$$
$$C_f + 2.5P_d = A_4 \qquad (4)$$
$$C_e + 7.8P_d = A_5 \qquad (5)$$
$$C_s + 411(P_d/I_d) = A_6 \qquad (6)$$

Two given variables are involved in these equations. They are (1) L, the total population eating out of civilian supplies, in millions, and (2) I_d, wholesale prices of all commodities in this country as computed by the Bureau of Labor Statistics (1926=100). They cannot be included in the modified constants because they appear as a multiplier or divisor, respectively, of P_d.

By subtracting the last 4 equations from equation (2) and solving the resulting equation for P_d, the following formula is given:

$$P_d = \frac{A_2 - LA_3 - A_4 - A_5 - A_6}{-0.0015L - (411/I_d) - 10.3} \qquad (7)$$

Once a value for P_d is obtained, equations (3) to (6) can be solved directly, after inserting values for L and I_d, to obtain the 4 price-determined utilizations.

We are now ready to discuss how these analyses can be used to answer specified policy questions. Four types of questions are considered.

Effects of Eliminating Price Supports for Wheat While Retaining Them for Corn

For a number of commodities, the price-support program is retained at full rates only if a specified percentage of producers vote in favor of marketing quotas. This is true for wheat. In the spring of 1955, many people believed that producers might vote down marketing quotas for wheat; there is always the possibility that this might happen in later years. Questions were therefore raised as to what might happen to wheat prices if quotas were defeated. As no marketing quotas were involved for corn, it was logical to assume that the current support program would remain unchanged. From an analytical standpoint, this simplified the computations because, in the study for wheat, corn prices could be taken as given.

At the time the analysis was made, producers already had accepted quotas for the 1956 crop. Hence, the earliest year for which quotas could be rejected was the marketing year beginning in 1957. Separate estimates were made for each year beginning July from 1957–58 through 1960–61. On a judgment basis, it was assumed that production of wheat, with no restrictions on acreage, might increase to 1,080 million bushels, compared with 860 million bushels in 1955. Commercial stocks on July 1, 1957, were taken at 60 million bushels, about the same as for the same date in 1955; and it was assumed that stocks held under the support program could be impounded in such a way that farmers and members of the trade would know that these stocks would *not* affect domestic or world prices of wheat. In a study discussed in a later section of this article, an indication is given as to what might happen to prices if these stocks were released or "dumped" directly into commercial channels.

Prices of corn were taken at levels equivalent to those that might be expected under the support program if it were operated under existing legislation, assuming no change in the parity index from the level of mid-1955. A gradual decline in the price of corn was indicated, reflecting a continued build-up in supplies and a shift from "old" to "new" parity. Expected supplies of wheat in this country, less stocks impounded, were used in deriving expected world supplies, and population, poultry units, and "time" were based on expected values for the given years. Other given variables were taken at the same level as in 1954–55, the latest year for which data were available at the time of the study. The analysis is thus based on the assumption that economic conditions outside the grain economy shall remain at about the current level.

Two modifications in the system of equations shown on p. 34 were made.

The first involves the substitution of a curvilinear relationship between prices of wheat and the quantity of wheat fed to livestock for the linear relationship that is believed to apply when the spread between the price of wheat and the price of corn used in the analysis is between zero and 40 cents per 60 pounds (the weight of a bushel of wheat). For larger price spreads, requirements for wheat in poultry and other rations is more than the quantity indicated by the linear analysis. Thus, when use for feed is plotted on the vertical scale, a slope that becomes less steep is required. When the price of wheat approaches or falls below the comparable price of corn, use of wheat for feed increases rapidly and by more than that suggested by the linear relationship. For this part of the curve, a slope that becomes increasingly steep is required. When the price spread is outside the specified range, the quantity of wheat fed frequently can be estimated approximately by making use of a logarithmic relation between prices of wheat and quantity fed. This computation is described in detail on pages 89 to 93 of Technical Bulletin 1136.[2] Use of a curvilinear relation of this sort was required for all years for the data shown in the upper part of table 1 and for the year beginning 1957 in the lower part of the table. Considerations involved

[2] Computations involved in incorporating results from the logarithmic equation in the system of equations are similar to those discussed on p. 37 involving a similar incorporation of results from the logarithmic analysis for prices of corn.

in developing the logarithmic analysis are described in detail on pages 23 to 25 of the bulletin on wheat.

The second modification concerns equation (5) for exports. Because of the effect of institutional forces in the world today, it is believed that exports from this country that exceed specified levels will result in retaliatory action on the part of other governments. So long as our exports remain below these levels, it is likely that the same kind of economic forces will apply as those in the pre-World War II years on which the analysis was based. This adjustment in the system of equations can be made easily. The equations are first solved with no restriction on exports. If the indicated figure for C_e is higher than the specified maximum, the following formula is used to estimate P_d. In this formula, the symbol E is used to indicate the assumed maximum for exports.

$$P_d = \frac{A_2 - LA_3 - A_4 - E - A_6}{-0.0015L - (411/I_d) - 2.5} \qquad (7.1)$$

The reader can easily verify that this formula is obtained by substituting $C_e = E$ for equation (5), then deriving the formula for P_d by the same algebraic process as that used in the previous case. The other utilizations are obtained in the same way as previously. Table 1 shows results from the analysis when E is taken, respectively, as 400 and 300 million bushels. The latter quantity is probably more nearly representative of present-day conditions. Exports of 355 million bushels are indicated for the marketing year beginning in 1957 under the 400-million bushel maximum. This quantity was derived by making use of a price obtained from the original formula (7) for P_d. All of these computations assume the average export subsidy per bushel of wheat to be the same as in 1954–55.

One other minor modification was made to take account of the fact that, when questions of policy are considered, prices received by farmers rather than prices at a terminal market ordinarily are used. By using an analysis described on pages 70 to 71 of Technical Bulletin 1136, estimated prices of No. 2 Hard Winter wheat at Kansas City as obtained from the system of equations were converted to an equivalent price received by farmers. If P'_d is used to represent the price received by farmers in cents per bushel, the relationship is as follows:

$$P'_d = -5.4 + 0.92\, P_d \qquad (8)$$

TABLE 1.—*Wheat: Estimated price, supply, and utilization with a price-support program for corn but no program for wheat and with stocks of wheat under the loan program as of July 1, 1957, impounded, 1957–60* [1]

Exports restricted to not more than 400 million bushels

Item	Unit	Year beginning July 1957	1958	1959	1960
Price received by farmers per bushel.	Cts	195	190	180	175
Supply:					
Production	Mil. bu	1,080	1,080	1,080	1,080
Beginning stocks	do	60	120	140	160
Total	do	1,140	1,200	1,220	1,240
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	480	475	475	475
Feed	do	110	110	110	110
Export	do	355	400	400	400
Ending stocks	do	120	140	160	180

Exports restricted to not more than 300 million bushels

Item	Unit	1957	1958	1959	1960
Prices received by farmers per bushel.	Cts	175	145	125	115
Supply:					
Production	Mil. bu	1,080	1,080	1,080	1,080
Beginning stocks	do	60	170	260	310
Total	do	1,140	1,250	1,340	1,390
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	485	490	490	490
Feed	do	110	125	165	190
Export	do	300	300	300	300
Ending stocks	do	170	260	310	335

[1] Impounded stocks are assumed to have no effect on domestic or world prices.

Several inferences can be made from the data shown in table 1. Under the more realistic assumption with respect to exports, prices decline to \$1.15 per bushel for the last year shown. As farmers and the trade might anticipate a decline of this kind, it is possible that prices for earlier years would sag below those suggested by the analysis. The analysis suggests that if exports somehow could be increased to around 420 million bushels a year, prices might remain at around \$1.90 per bushel, *once present surpluses are disposed of*, even though production controls were eliminated.

in developing the logarithmic analysis are described in detail on pages 23 to 25 of the bulletin on wheat.

The second modification concerns equation (5) for exports. Because of the effect of institutional forces in the world today, it is believed that exports from this country that exceed specified levels will result in retaliatory action on the part of other governments. So long as our exports remain below these levels, it is likely that the same kind of economic forces will apply as those in the pre-World War II years on which the analysis was based. This adjustment in the system of equations can be made easily. The equations are first solved with no restriction on exports. If the indicated figure for C_e is higher than the specified maximum, the following formula is used to estimate P_d. In this formula, the symbol E is used to indicate the assumed maximum for exports.

$$P_d = \frac{A_2 - LA_3 - A_4 - E - A_6}{-0.0015L - (411/I_d) - 2.5} \qquad (7.1)$$

The reader can easily verify that this formula is obtained by substituting $C_e = E$ for equation (5), then deriving the formula for P_d by the same algebraic process as that used in the previous case. The other utilizations are obtained in the same way as previously. Table 1 shows results from the analysis when E is taken, respectively, as 400 and 300 million bushels. The latter quantity is probably more nearly representative of present-day conditions. Exports of 355 million bushels are indicated for the marketing year beginning in 1957 under the 400-million bushel maximum. This quantity was derived by making use of a price obtained from the original formula (7) for P_d. All of these computations assume the average export subsidy per bushel of wheat to be the same as in 1954–55.

One other minor modification was made to take account of the fact that, when questions of policy are considered, prices received by farmers rather than prices at a terminal market ordinarily are used. By using an analysis described on pages 70 to 71 of Technical Bulletin 1136, estimated prices of No. 2 Hard Winter wheat at Kansas City as obtained from the system of equations were converted to an equivalent price received by farmers. If P_d' is used to represent the price received by farmers in cents per bushel, the relationship is as follows:

$$P_d' = -5.4 + 0.92\, P_d \qquad (8)$$

TABLE 1.—*Wheat: Estimated price, supply, and utilization with a price-support program for corn but no program for wheat and with stocks of wheat under the loan program as of July 1, 1957, impounded, 1957–60* [1]

Exports restricted to not more than 400 million bushels

Item	Unit	Year beginning July 1957	1958	1959	1960
Price received by farmers per bushel.	Cts	195	190	180	175
Supply:					
Production	Mil. bu	1, 080	1, 080	1, 080	1, 080
Beginning stocks	do	60	120	140	160
Total	do	1, 140	1, 200	1, 220	1, 240
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	480	475	475	475
Feed	do	110	110	110	110
Export	do	355	400	400	400
Ending stocks	do	120	140	160	180

Exports restricted to not more than 300 million bushels

Item	Unit	1957	1958	1959	1960
Prices received by farmers per bushel.	Cts	175	145	125	115
Supply:					
Production	Mil. bu	1, 080	1, 080	1, 080	1, 080
Beginning stocks	do	60	170	260	310
Total	do	1, 140	1, 250	1, 340	1, 390
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	485	490	490	490
Feed	do	110	125	165	190
Export	do	300	300	300	300
Ending stocks	do	170	260	310	335

[1] Impounded stocks are assumed to have no effect on domestic or world prices.

Several inferences can be made from the data shown in table 1. Under the more realistic assumption with respect to exports, prices decline to $1.15 per bushel for the last year shown. As farmers and the trade might anticipate a decline of this kind, it is possible that prices for earlier years would sag below those suggested by the analysis. The analysis suggests that if exports somehow could be increased to around 420 million bushels a year, prices might remain at around $1.90 per bushel, *once present surpluses are disposed of*, even though production controls were eliminated.

This can be compared with the expected price of $2.00 for 1955–56 under the present program. However, even if present "surpluses" were, in effect, completely eliminated, prices apparently would decline rapidly to a relatively low level unless either (1) production controls were retained, or (2) exports could be increased materially. In the table, ending stocks are shown as a residual; in the analysis they were obtained simultaneously with utilization items other than seed and industrial.

Effect of "Elimination of Surpluses" in 1955–56 Given Existing Support Programs

Another question of interest is "What would happen to agricultural prices if we got rid of our burdensome surpluses?" For wheat, a partial answer is given by the preceding example. But we may also ask, What price would prevail during the 1955–56 marketing year if stocks under loan, or held by the Commodity Credit Corporation as of the start of the year, were impounded so as to nullify their effect on market prices? The basic analyses discussed in the first section of this article can be used to provide an answer to this question as it applies to wheat and corn.

On the surface, the problem looks fairly simple. Stocks of wheat other than those in commercial hands on July 1, 1955, were 990 million bushels, and similar stocks of feed grains that enter into the supply of total feed concentrates at the beginning of the 1955–56 marketing season were 30 million tons. The latter includes stocks of oats and barley under loan or owned by the Commodity Credit Corporation as of July 1, and stocks of corn and sorghum grains as of October 1. One might assume that the answer might be reached by deducting these stocks from the total supplies in the respective analyses, inserting expected values for the other given variables, and obtaining expected values for the various dependent variables. But the quantity of wheat fed depends partly on the price of corn, and the price of corn depends to some extent on the quantity of wheat fed. Hence, it seemed desirable to modify the system of equations for wheat so that the price of corn could be included among the simultaneously determined variables.

If the analysis for corn had been based on a linear, rather than a logarithmic, relationship, this could have been done easily. In the next few paragraphs we discuss how a linear relationship was derived from the logarithmic one for corn. The linear relation can be used as an approximation for the logarithmic if changes in X_1 from the initial value are small.[3]

To simplify the discussion, we first rewrite equation (1.1) by substituting the letter b for the numerical value of the regression coefficient. Thus $b = -1.82$. The equation then reads:

$$\log X'_0 = \log A_1 + b \log X_1 \qquad (1.2)$$

If we translate this equation into actual numbers (rather than logarithms) we obtain:

$$X'_0 = A_1 X_1^{b} \qquad (1.3)$$

We now borrow a notion from differential calculus. To get the slope of a curve at any given point, we need to evaluate the first derivative at that point. The first derivative of the function (1.3) with respect to X_1 is:

$$\frac{dX'_0}{dX_1} = bA_1X_1^{b-1} \qquad (9)$$

Inserting the value for b, we get:

$$\frac{dX'_0}{dX_1} = -1.82A_1X_1^{-2.82} \qquad (9.1)$$

We wish to evaluate the slope of the line when X_1—total supply of feed concentrates—is at its expected level, for the particular analysis, making use of the appropriate value of A_1. As of the start of the analysis, we know all values that enter into X_1 except the quantity of wheat to be fed during the crop year, and that we can estimate approximately. In most instances, an error of as much as 100 percent in our advance estimate of the quantity of wheat fed will affect X_1 by only a few percentage points (as the quantity of wheat fed normally constitutes only about 2 percent of the total supply of feed concentrates) and will affect the estimate of the slope of the line even less. If the initial estimate of the quantity of wheat fed is found to be badly off, after making the computations for the system of equations, so that the computed linear relationship is a poor approximation to the true curve, we can always make a better approximation by using a revised

[3] This general approach is described by ALLEN, R. G. D., MATHEMATICAL ANALYSIS FOR ECONOMISTS, Cambridge Univ. Press, New York, 1947, page 145. It was developed independently in this study by the authors.

This can be compared with the expected price of \$2.00 for 1955–56 under the present program. However, even if present "surpluses" were, in effect, completely eliminated, prices apparently would decline rapidly to a relatively low level unless either (1) production controls were retained, or (2) exports could be increased materially. In the table, ending stocks are shown as a residual; in the analysis they were obtained simultaneously with utilization items other than seed and industrial.

Effect of "Elimination of Surpluses" in 1955–56 Given Existing Support Programs

Another question of interest is "What would happen to agricultural prices if we got rid of our burdensome surpluses?" For wheat, a partial answer is given by the preceding example. But we may also ask, What price would prevail during the 1955–56 marketing year if stocks under loan, or held by the Commodity Credit Corporation as of the start of the year, were impounded so as to nullify their effect on market prices? The basic analyses discussed in the first section of this article can be used to provide an answer to this question as it applies to wheat and corn.

On the surface, the problem looks fairly simple. Stocks of wheat other than those in commercial hands on July 1, 1955, were 990 million bushels, and similar stocks of feed grains that enter into the supply of total feed concentrates at the beginning of the 1955–56 marketing season were 30 million tons. The latter includes stocks of oats and barley under loan or owned by the Commodity Credit Corporation as of July 1, and stocks of corn and sorghum grains as of October 1. One might assume that the answer might be reached by deducting these stocks from the total supplies in the respective analyses, inserting expected values for the other given variables, and obtaining expected values for the various dependent variables. But the quantity of wheat fed depends partly on the price of corn, and the price of corn depends to some extent on the quantity of wheat fed. Hence, it seemed desirable to modify the system of equations for wheat so that the price of corn could be included among the simultaneously determined variables.

If the analysis for corn had been based on a linear, rather than a logarithmic, relationship, this could have been done easily. In the next few paragraphs we discuss how a linear relationship was derived from the logarithmic one for corn. The linear relation can be used as an approximation for the logarithmic if changes in X_1 from the initial value are small.[3]

To simplify the discussion, we first rewrite equation (1.1) by substituting the letter b for the numerical value of the regression coefficient. Thus $b = -1.82$. The equation then reads:

$$\log X'_0 = \log A_1 + b \log X_1 \qquad (1.2)$$

If we translate this equation into actual numbers (rather than logarithms) we obtain:

$$X'_0 = A_1 X_1^{b} \qquad (1.3)$$

We now borrow a notion from differential calculus. To get the slope of a curve at any given point, we need to evaluate the first derivative at that point. The first derivative of the function (1.3) with respect to X_1 is:

$$\frac{dX'_0}{dX_1} = bA_1X_1^{b-1} \qquad (9)$$

Inserting the value for b, we get:

$$\frac{dX'_0}{dX_1} = -1.82A_1X_1^{-2.82} \qquad (9.1)$$

We wish to evaluate the slope of the line when X_1—total supply of feed concentrates—is at its expected level, for the particular analysis, making use of the appropriate value of A_1. As of the start of the analysis, we know all values that enter into X_1 except the quantity of wheat to be fed during the crop year, and that we can estimate approximately. In most instances, an error of as much as 100 percent in our advance estimate of the quantity of wheat fed will affect X_1 by only a few percentage points (as the quantity of wheat fed normally constitutes only about 2 percent of the total supply of feed concentrates) and will affect the estimate of the slope of the line even less. If the initial estimate of the quantity of wheat fed is found to be badly off, after making the computations for the system of equations, so that the computed linear relationship is a poor approximation to the true curve, we can always make a better approximation by using a revised

[3] This general approach is described by ALLEN, R. G. D., MATHEMATICAL ANALYSIS FOR ECONOMISTS, Cambridge Univ. Press, New York, 1947, page 145. It was developed independently in this study by the authors.

value for X_1 and then making a new set of computations for the system.[4] Let us designate the answer obtained from (9.1) as B. The reader should note that logarithms are needed to evaluate the expression $X_1^{-2.82}$.

We now wish to obtain a linear equation that has the slope B and that passes through the point on the original logarithmic curve at the chosen value for X_1. By substituting the estimated value of X_1 in equation (1.1), we can obtain an estimated value for X_0 at that point. Let us designate these numbers by the symbols $\hat{X}_0$, $\hat{X}_1$. We now can write the equation of the desired linear relation as:

$$X'_0=(\hat{X}_0-B\hat{X}_1)+BX_1 \qquad (10)$$

The reader who remembers his elementary analytical geometry will see that this is the equation of a line for which we know the slope and 1 point.

We must now effect some further transformations to make equation (10) apply to the variables included in the system of equations for wheat. For the combined analysis, all of X_1 is assumed to be given except the quantity of wheat fed. This can be allowed for in the equation by letting

$$X_1=X_1''+C_f'' \qquad (11)$$

BX_1'' then can be combined with the other constant terms in the equation. The symbol C_f'' is used because this is in terms of million tons, while C_f, as used in the system of equations for wheat, is in million bushels. The relationship between C_f'' and C_f is given by:

$$C_f''=\frac{60}{2{,}000}C_f \qquad (12)$$

In the system of equations for wheat, the price of corn, P_c, relates to 60 pounds of No. 3 Yellow at Chicago, average for July–December, in cents, whereas X_0 is the average price received by farmers per standard or 56-pound bushel, average for November–May, in cents. A relationship between P_c and X_0 can be developed in several ways, one of which follows: (1) Based on the computation discussed on page 12 of Technical Bulletin 1070, the season-average price received by farmers for corn equals approximately $X_0/0.95$.

[4] In the analyses discussed here, three iterations normally were required to verify that the answers were correct to the nearest cent on prices and the nearest million bushels on utilization.

(2) Based on an analysis referred to on page 65 of Technical Bulletin 1061, the annual average price of No. 3 Yellow corn at Chicago equals the annual price received by farmers for all corn times 1.05 plus 1.11 cents. (3) Based on index numbers of normal seasonal variation for No. 3 Yellow corn at Chicago as shown on page 50 of that bulletin, the July–December price at Chicago equals 1.017 times the annual price. (4) The price of 60 pounds of corn naturally equals 60/56 times the price of a standard bushel. By combining these relationships, we find that

$$X_0=0.83P_c-1.004 \qquad (13)$$

If we make the three substitutions implied by equations (11), (12), and (13), we can rewrite equation (10) as

$$P_c=1.\hat{2}(X_o-\hat{B}X_1+BX_1''+1.004)''+0.036\,BC_f \qquad (10.1)$$

By letting $A_7=1.2(\hat{X}_o-B\hat{X}_1+BX_1''+1.004)$ and $b_{71}=0.036B$, we can rewrite this as

$$P_c=A_7+b_{71}C_f \qquad (10.2)$$

The equation in this form is used in the rest of the discussion. In following it, one should keep in mind the substantial number of computations involved in obtaining A_7 and b_{71}.

We are now ready to consider the system of equations that includes (10.2). Referring to page 34, if equations (3), (5), and (6) are subtracted from equation (2), equation (14) shown below is given. Equation (4) now must be modified to show P_c as a separate variable. This is done by removing $2.5P_c$ from A_4 and transposing this term to the opposite side of the equality sign. The modified equation is designated as equation (4.1) in the system shown below, and the modified A_4, as A'_4. Equations (14), (4.1), and (10.2) can be written conveniently as follows:

$$\begin{array}{lllr}
C_f-(0.0015L+7.8+411/I_d)P_d & & =A_2-LA_3-A_5-A_6 & (14)\\
C_f & +2.5P_d & -2.5P_c=A'_4 & (4.1)\\
-b_{71}C_f & & +P_c\quad =A_7 & (10.2)
\end{array}$$

If equation (10.2) is multiplied by -2.5 and subtracted from equation (4.1), the following equation results:

$$(1-2.5b_{71})C_f+2.5P_d=A_4'+2.5A_7 \qquad (15)$$

If equation (14) is multiplied by $(1-2.5b_{71})$ and subtracted from equation (15), a formula for P_d can be derived directly. To write this in algebraic symbols is somewhat complicated but, when working with numbers in an actual problem, it would be very simple. A value for C_f then can be obtained from equation (14), P_c can be obtained from equation (10.2), and the other price-determined utilizations for wheat can be obtained easily from the initial equations.

This approach was used to estimate the effects on prices of wheat and corn if stocks controlled by the Government as of the start of the 1955–56 marketing year were impounded so that they could not affect domestic or world prices. Results are shown in table 2. The stocks impounded are shown in the row for Government stocks. To show the effect of export subsidies, two sets of computations were made. One assumes the same average export subsidy per bushel as in 1954–55, whereas the other assumes no export subsidies. Prices shown in the last column are those that are expected by commodity analysts to prevail under the support programs in 1955–56. Utilization for food, feed, export, and commercial carryover were obtained from the system of equations, making use of the expected levels of prices for wheat and corn. Government stocks were taken as a residual. In making these computations, export subsidies were assumed to be at the same rate per bushel as in 1954–55. In all instances, quantitities fed were computed by making use of the logarithmic analysis referred to on page 35.

Comparison of the prices shown in the first and last columns suggests that stocks controlled by the Government are fairly effectively isolated from the market under existing conditions. Their complete elimination, as implied by the first set of computations, would result in price increases of not more than 10 percent.

The average export subsidy in 1954–55 was 38.5 cents per bushel. This was computed by taking subsidies paid per bushel under the International Wheat Agreement times the number of bushels shipped under the agreement and dividing by total exports during the marketing year. Comparison of the prices shown in the first 2 columns of table 2 suggests that prices of all wheat might decline by about 25 cents a bushel if this subsidy were eliminated, but that prices of corn would be approximately unaffected. The analysis suggests that exports with no subsidy would decline substantially.

The reader may question why commercial stocks, as shown in the last column, are so much higher than those shown in the first column, whereas all other price-determined utilizations are about the same in the two columns. This reflects a number of factors. Use for food and feed are nearly the same because demand for each under the conditions specified is highly inelastic. Exports are about the same because, whereas domestic prices are somewhat lower in the last than in the first column, world prices as estimated from the system of equations also are lower when all stocks are included in supply; the difference between world and domestic prices affects exports rather than the level of either series separately. Thus the only series which reflects much change as a result of the lower domestic prices is the level of stocks. Commercial stocks on July 1, 1956, are likely to be lower than the 110 million bushels suggested by the system of equations, but exports probably will be larger than the 170 million bushels indicated because of special Governmental programs not taken into account by the system.

TABLE 2.—*Estimated prices of wheat and corn and utilization of wheat with Government stocks as of the beginning of the 1955–56 marketing year impounded, as compared with expected values under existing conditions, marketing year beginning 1955* [1]

Item	Unit	Stocks impounded and export subsidy at— Same level as in 1954–55	Stocks impounded and export subsidy at— Zero	Existing conditions with export subsidy at same level as in 1954–55
Price received by farmers per bushel:				
Corn	Cts.	130	130	125
Wheat	do	220	195	200
Wheat:				
Utilization:				
Food	Mil. bu.	500	505	505
Feed	do	105	110	105
Export	do	175	95	170
Seed and industrial	do	75	75	75
Ending stocks:				
Commercial	do	60	130	110
Government	do	990	990	[2] 940

[1] Stocks impounded are assumed to have no effect on domestic or world prices.
[2] Residual.

Effect of Eliminating Price Supports for Both Wheat and Corn

Another kind of analysis that can be made is to estimate free-market prices for commodities currently in surplus under assumptions such as (1) that all stocks under loan or held by CCC are dumped on the market in a single year; and (2) that these stocks are disposed of in such a way as to have no effect on market prices. As we can think of no way in which such a disposal could be carried out, the second assumption is reworded to conform to that in previous examples, that is, that stocks are impounded in such a way as to have no effect on domestic or world prices.

Estimates were made for marketing years beginning in 1956 and in 1959, with all dumping assumed to take place in 1956. The year 1959 was chosen to allow for some longer range adjustments. In some instances, estimates for wheat and corn also were made for intervening years; results shown here are for the 2 periods only. We naturally assumed that acreage controls were eliminated. Basic assumptions of the magnitude of certain supply variables are shown in table 3, together with results of the analysis. For all estimates, the general level of economic activity was taken to be the same as that prevailing in 1953–54. Subsequent tests compared results based on this level with those obtained under conditions prevailing in 1954–55. Only minor differences were indicated.

In deriving A_1, the number of animal units with Government stocks impounded was assumed to be the same as the expected number for 1955–56; with Government stocks included in the commercial supply, an increase of 6 percent above 1955–56 was assumed. This is about as large an increase as would be expected in a single year under the assumed conditions. To estimate an associated price for livestock products, this number of animal units was used in an equation given on page 21 of Technical Bulletin 1070, assuming no change in disposable income from the level of the previous year. These 2 variables—animal units and prices of livestock products—are involved in the computation of A_1.

Results shown in columns 1 and 3 of table 3 were obtained directly from the system of equations. An adjustment for feed of the kind described on p. 35 should have been made for the year beginning in 1956, with Government stocks impounded, but the resulting error was believed to be so small th[at] further manipulation of the model was regarde[d] as unwarranted. A figure of around 100 million bushels probably would have been obtained instead of 75 million bushels as shown in the table.

When Government stocks were assumed to be sold through commercial channels for the year beginning in 1956, and exports were restricted to not more than 400 million bushels, a direct solution of the equations gave a price estimate of 3 cents a bushel for wheat at Kansas City and 93 cents for corn at Chicago. The reason for this implausible result is as follows: When the price of wheat falls to near or below that for corn, the demand for wheat for feeding is much more elastic than when the price is considerably above that for corn. The logarithmic analysis for wheat fed could not be used in this instance because the logarithm of a negative number is undefined. The following method was used instead: A 20-cent negative differential between prices received by farmers for wheat and corn seemed like a maximum, and the regression coefficient for (P_d–P_c) in equation (4.1) was adjusted in such a way as to reduce the negative price differential to this level.[5]

The algebra involved in obtaining the adjusted coefficient is rather complicated and need not b[e] shown in detail here. The general approach is as follows: (1) By making use of the relationships previously described between prices received by farmers and prices at specified terminal markets, the algebraic value for P_d–P_c that is equivalent to a negative spread of 20 cents at the farm level can be obtained. Let this algebraic value equal M. (2) Equation (4.1) (see p. 38) is modified to substitute a regression coefficient for P_d–P_c that is unknown for the value of 2.5 used under normal circumstances. Call this coefficient K. (3) M is substituted for P_d–P_c in equation (4.1) and P_d–M is substituted for P_c in equation (10.2). This eliminates P_c from the equations.

[5] A negative differential of this magnitude seems reasonable if supplies of wheat available for feeding relative to demand are expected to be extremely large. In certain analyses made after the writing of this article, supplies of wheat available for feeding were expected to be much larger than normal but the demand for feed also was expected to be abnormally large. Here a zero differential between P_d and P_c was used, that is, P_d was not permitted to be less than P_c. The basic algebraic formulation is the same in either case.

TABLE 3.—*Estimated price, supply, and utilization of wheat and feed concentrates with no price-support operations, marketing years beginning 1956 and 1959*

Item	Unit	With Government stocks at the beginning of the 1956 marketing year—				
		Impounded [1]		Included as part of total supply		
		1956	1959	No restriction on exports, 1956	Exports restricted to not more than 400 million bushels	
					1956	1959
Price per bushel received by farmers:						
Wheat	Cts	165	124	88	56	115
Corn	do	119	115	87	76	114
Wheat:						
Production	Mil. bu	1, 160	1, 160	1, 160	1, 160	1, 160
Stocks	do	50	300	925	925	355
Total supply	do	1, 210	1, 460	2, 085	2, 085	1, 515
Utilization:						
Seed and industrial	do	86	86	86	86	86
Food	do	479	495	506	515	498
Feed	do	75	177	204	601	205
Export	do	375	400	890	400	400
End-of-year storage	do	194	302	398	483	327
Feed concentrates:						
Production of feed grains	Mil. tons	120	120	120	120	120
Wheat fed	do	2	5	6	18	6
Other feeds fed	do	24	24	24	24	24
Stocks	do	12	12	35	35	9
Total supply	do	158	161	185	197	159
Utilization:						
Feed	do	130	133	146	156	133
Food, industry, seed, export	do	16	16	21	21	16
End-of-year storage	do	12	12	18	20	10
Grain-consuming animal units [2]	Mil	174	176	183	183	182
Feed fed per animal unit [2]	Tons	. 75	. 76	. 80	. 85	. 73

[1] Impounded stocks are assumed to have no effect on domestic or world prices.

[2] Livestock numbers and rates of feeding are based on estimates made prior to the recent revisions based on 1954 census data.

(4) Equations (14), (4.1), and (10.2) now contain 3 unknowns—C_f, P_d, and K. As some of the equations may be nonlinear, part of the solution of them may need to be made graphically. Once values for C_f, P_d, and K have been obtained, the other desired unknowns can be obtained easily. A regression coefficient of 11 instead of 2.5 was used in obtaining the estimates shown in the next to the last column.

Estimates for the year beginning in 1959, when Government stocks are impounded, are based on a beginning carryover of 300 million bushels of wheat. This quantity was chosen, after some experimentation, because it appeared to represent an equilibrium; ending stocks, as derived from the system of equations, are 302 million bushels.

Data shown in the last column were obtained year by year by using the following general approach: (1) The number of animal units to be fed was estimated by commodity specialists on our staff, making use of the estimates of feed prices and carryover of feed concentrates from the statistical analysis for the previous year. Originally, we had expected to make these estimates from an equation described on page 14 of Technical Bulletin 1070, but this appears to be no longer applicable.[6] (2) An associated price for livestock was obtained in the way described on p. 40. (3) These results were used to obtain an estimate of A_1, and the remaining computations were carried out in the usual way, using as beginning stocks the carryover from the preceding year.

End-of-year carryover for wheat decreased continuously and was still decreasing in 1959. Hence, somewhat higher prices than those shown for the year beginning in 1959 would be anticipated at a long-run equilibrium level. Utilization estimates for feed were made on a judgment basis by Malcolm Clough of our staff taking into consideration probable livestock numbers and the rate of feeding per animal unit with the given feed grain supplies and the derived prices of feed. The carryover for feed was taken as a residual, except for a restriction that stocks could not fall below a minimum working level.

Results shown in table 3 with Government stocks impounded can be compared with those in the upper section of table 1 to indicate the effect of a price-support and acreage-control program for corn and other crops on the price of wheat. Contrary to what might be expected on first thought, production of wheat was assumed to average around 1,080 million bushels with controls for other crops and to increase to 1,160 million bushels if these controls were eliminated. This assumed change grows out of a consideration of the effects of acreage controls on other crops that compete for land with wheat. When allowance is made for the expected difference in production of wheat, price supports and acreage-control programs for other crops apparently affect the price of wheat considerably. If a comparison that makes no allowance for a change in production of wheat is desired it can be obtained by comparing the data in table 3 with those in the lower section of table 1, as a difference of 100 million bushels for export would about compensate for the 80-million bushel difference in production. When the comparison is made in this way, prices for wheat when a program is in effect for corn are found to be only slightly higher than prices for wheat when no program exists for corn.

[6] The animal unit series is a weighted aggregate of the various groups of livestock on farms. More reliable projections of the total number of animal units can be derived by obtaining individual estimates of livestock numbers from the livestock commodity specialists, and combining these into the animal unit series, than by deriving the aggregate number from statistical relationships. This is especially true if the projection is made for only a year or two ahead, as reports on plans of farmers and current trends in numbers can be taken into account. For more distant projections, the statistical equations might yield better results than those obtained on a judgment basis.

Effects of a Multiple-Price Plan for Wheat

On pages 49 to 50 of Technical Bulletin 1136, Meinken describes how his system of equations can be used to study the effect of multiple-price plans. Suppose a 2-price plan is in effect under which wheat used for domestic food consumption is sold at a price equivalent to 100 percent of parity, while the remaining wheat sells at a free-market price. The amount of wheat used for food could be estimated from equation (3) (see p. 34) based on a value for P_d equivalent to the parity price. Suppose this amount is $\hat{C}_h$. The equation $C_h = \hat{C}_h$ is substituted for equation (3), and the system is solved for the other variables in the same way as described on p. 34.

If the Government were to place a floor under the "free" price at say 50 percent of parity, an estimate of the quantity of wheat going under the support program at this price, if any, could be obtained as a residual after computing the expected utilizations and commercial carryover. If the Government established a price for wheat used for food and a lower price for wheat used for feed, an approach similar to that described above could be used to solve for the expected utilizations for food and feed and the free-market price at which the remaining wheat would sell. Computations of this sort are relatively easy, but, as with the other analyses discussed in this study, many assumptions must be made.

Summary

This article describes four types of policy questions for wheat and corn that can be analyzed by using the research results contained in three recently-issued technical bulletins. Emphasis is placed on the algebraic manipulations required to allow for special circumstances. It is believed by some economic analysts that mathematical systems of equations are inflexible and difficult to adjust to allow for special circumstances; cases described in this article show this not to be true. Structural models are highly flexible and they can be modified to allow for many special circumstances. Moreover, results from the analysis can be combined with judgment estimates on the part of commodity specialists when this appears desirable. The advantages that a structural analysis of this kind has over one based entirely on judgment are that all interrelated estimates automatically are consistent, one with another, and account automatically is taken of those statistical relationships that are believed to be valid.

The Farmer's Share: Three Measurements

By Kenneth E. Ogren

The United States Department of Agriculture has long published statistics on the farmer's share of the consumer's food dollar based on a "market-basket" series. Questions frequently arise as to the interpretation of these statistics. This article describes the meaning of this series and considers two other series that can be used both to measure the part of consumers' food expenditures going to farmers and to provide other useful measurements in analyzing trends in marketing services and charges.

STATISTICS on the farmer's share of the consumer's food dollar published regularly by the Agricultural Marketing Service in *The Marketing and Transportation Situation* and other periodicals have received much public attention in recent years. This interest has been stimulated by the almost continuous decline in the farmer's share since early in 1951.

Consumer expenditures for food products are made up of two parts: (1) Payments going to farmers, which represent primarily the returns for the production of raw materials used in food products, and (2) payments going to agencies that assemble and process these raw materials and perform other functions necessary to get food products to consumers in the form, time, and place desired. For purposes of this article, the second group are referred to as payments for "marketing services."

Variations in services performed in marketing a product or group of products must be considered in any comparisons of farmer's shares. The extent of these marketing services may change because of shifts in kinds and relative quantities of food bought by consumers. Shifts in distribution channels, such as the buying of more restaurant meals, affect total marketing services. Shifts in production and population centers also affect transportation and other marketing services required. Therefore, any interpretation of changes in the farmer's share of the food dollar over time, or of variations between products and product groups, should be considered in relation to variations and trends in marketing services.

The farmer's share calculated from the "market-basket" statistics compares urban retail-store prices of farm food products with payments received by farmers for equivalent quantities of produce. The purpose of this article is (1) to discuss the calculation and interpretation of this series and (2) to consider two other series from which a farmer's share may be derived. One of the two other series is derived from a comparison of total consumer expenditures for farm food products with the total farm receipts from sale of these products by United States farmers (adjusted for value of inedible byproducts). The other compares the same total consumer expenditures with the "value added" by agriculture, that is, the gross returns received by agriculture for its labor and capital, excluding the cost of purchased production materials and services.