16.

Aggregate Commodity Supply Function and Income Adjustments

THE INCOME PROBLEMS of agriculture arise mainly from the nature of product supply and resource demand functions and their short-run and long-run elasticities. We have illustrated, within the static framework of Chapters 2 and 6, that commodity supply response depends on the productivity of resources and their sensitivity to price changes. Several approaches are possible for estimating aggregate supply response and its income effects. Optimally, we would desire to incorporate factor demand and product supply into a single, complete simultaneous system and, from knowledge of the predetermined policy variables, predict the organization and income of agriculture at various points in the future under alternative policies.

The attempts to estimate such an interdependent model in this study have not been very successful. In this chapter, however, we do attempt to predict the results of a restricted set of policy alternatives from single-equation least-squares demand and supply functions. The commodity supply elasticity is determined by direct estimates and also from the production function in Chapter 4 and the input demand functions in Chapters 12 and 13. The estimates of commodity supply and policy implications for various time periods have mainly methodological importance but, it is hoped, also have predictive value.

Greater knowledge of the aggregate agricultural supply function is essential for informed national policy. Policy debate has revolved around the nature of the supply function and its elasticity. At one extreme has been the proposition that the supply function is backward sloping and has a negative elasticity because farmers increase output to meet fixed expenses when commodity prices fall. Under this condition, a reduction in support prices or return to free markets would cause output to increase, thus aggravating the problem of depressed income. At another extreme is the proposition that the supply elasticity is sufficiently great to bring needed resource, output and income adjustments in a short time. Under this condition, a drop in support price or return to the free market would cause a relatively large decrease in output with only a small decrease in product price or income.

A more prevalent view is that the commodity supply curve is positively sloped but that supply is not sufficiently elastic even in the long run to cope with the "nonprice" influences shifting supply to the right.

These supply shifters are innovations which increase the quantities and productivities of resources, raising output and lowering returns to conventional resources. Quantitative measures of the supply elasticity and supply shifters can lead to more efficient public selection of farm programs.

In this chapter we attempt to measure both the time and size dimensions of aggregate supply response to price in agriculture. While still quantitatively imperfect, it is hoped that the analysis can help resolve some of the conflicting concepts about the nature of product supply in agriculture. The aggregate supply response depends fundamentally on the resource flexibility in agriculture. Hence, it is logical for this study emphasizing resources to turn its emphasis to an explanation of aggregate commodity supply. The procedure is to base estimates of supply indirectly on previously estimated input demand functions, and directly on separate estimates of the supply function. The U.S. farm output of crops and livestock is estimated by least squares. In addition, the sales of agricultural products (current output less changes in farm inventories) are estimated by least squares and by limited information simultaneous techniques.

Some excellent studies of supply response for several individual farm commodities have been made.[1] Unfortunately these studies provide but little basis for inferences about aggregate supply response. Opportunities for substituting one commodity for another are great because farm resources are flexible among commodities; i.e., the same resources can be used to produce any one of several products. Perhaps many inferences about aggregate supply response have been based on observations of the relatively large supply elasticities for individual commodities.

Several attempts have been made to determine the nature of aggregate supply response and resource flexibility in agriculture.[2] In general, these "less quantitative studies" lead to the conclusion that the supply elasticity in response to falling product prices is low because there are few short-run alternative uses outside agriculture for farm resources.

Griliches has made recent quantitative estimates of the aggregate output function, his most successful equations expressing output as a function of relative price, weather, trend and lagged output.[3] The price

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[1] For a bibliography and brief review of supply studies see: Knight, Dale A. Evaluation of time series as data for estimating supply parameters. In Heady, Earl O., Baker, C. B., Diesslin, Howard G., Kehrberg, Earl, and Staniforth, Sydney. Agricultural Supply Functions. pp. 74-104. Iowa State University Press. Ames. 1961.

[2] Cf. Heady, Earl O. The supply of U.S. farm products under conditions of full employment. American Economic Review, Papers and Proceedings. 45:228-38. 1958. Johnson, D. Gale. The nature of the supply function for agricultural products. American Economic Review. 40:722-29. 1951. Johnson, Glenn L. Supply functions - some facts and notions. In Heady, Earl O., Diesslin, Howard G., Jensen, Harald R., and Johnson, Glenn L. (eds.) Agricultural Adjustment Problems in a Growing Economy. Iowa State University Press. Ames. 1958.

[3] Griliches, Zvi. The aggregate U.S. farm supply function. Journal of Farm Economics. 42:282-93. 1960.

variable was specified as the ratio of prices received by farmers to prices paid by farmers for items used in production, including interest, taxes and wage rates on March 15 of the current year. Inclusion of relative price in the previous year, prices received deflated by prices paid for items used in production only (excluding interest, taxes and wage rates), farm wage rates, farm income, nonfarm income, unemployment in the nonfarm economy, land prices and lagged weather did not improve the least-squares equation. Inclusion of lagged output in the output function reduced the extent of autocorrelation in the residuals, but the coefficient of the lagged variable was highly sensitive to the specification of the time period and variables. Griliches' equations suggest that the short-run supply function is shifting to the right at the rate of 1.5 to 1.7 percent per year, with the shift accelerating in recent years.

SPECIFICATION AND ESTIMATION OF THE AGGREGATE SUPPLY FUNCTION FOR FARM PRODUCTS

Two measures of the agricultural supply quantity are used in this chapter. The first, agricultural output, O, is the production of feed and livestock during the current year, excluding inter-farm sales and crops fed to livestock. It represents the current product of agricultural resources available for eventual human consumption. The concept is considered the most relevant long-run measure of supply quantity since it is closely tied with the resource structure and is not influenced by fluctuations of nonproductive farm inventories.

The second measure of the supply quantity, Q_S, is output, O, less changes in farm inventories of livestock and feed. It measures the quantity of farm commodities entering the marketing system in a given year and is useful in explaining current farm prices. It can be a biased indicator of production because of inventory changes. Since there is no production period for farm inventories, decisions regarding the level of inventories can be based on current supply and demand for farm inputs and products. For this reason, the supply concept Q_S which includes inventory changes is estimated as part of an interdependent system of demand equations for farm products and demand and supply equations for farm inputs. The supply concept O is analyzed only by ordinary least squares. The assumption for the latter is that current output is predetermined by past prices, P_R/P_P, durable input levels, S_p, government programs, G, weather, W, and trend, T. The output supply function is

$$O_t = f((P_R/P_P)_{t-1}, S_{pt}, G_t, W_t, T). \tag{16.1}$$

A technology or productivity variable, T′, is the aggregate measure of output per unit of input in agriculture. It is composed of a long-term trend (approximately T) determined by efficiency (management, specialization, etc.) and technology (changes in the true physical production function). Short-term fluctuations in the productivity variable T′ are determined mainly by the weather. Thus, in a second formulation of (16.1), T′ is substituted for W and T. Given the level of inputs and T′, the output also is known. It follows that the variables P_R/P_P, S_p and G primarily are concerned with predicting the aggregate input level in agriculture. But with the beginning year stock of productive assets, S_p, in the function, only operating inputs, labor and current inputs of durables are left to be determined by P_R/P_P and G.

Since durable assets and labor have little short-run effect on output, the price variable primarily reflects the short-run influence of operating inputs. In one sense, equation (16.1) may be regarded as a dynamic agricultural production function with price substituted for the quantity of operating inputs. The supply equation is extremely simplified and is short run, but can be made long run by substituting an investment function for S_p from Chapter 12 into the supply function. The supply function is specified in a highly simplified form to avoid statistical complications. But from knowledge of the input structure (investment function) much can be learned about the nature of supply elasticity in agriculture.

There are several reasons for supposing that short-run supply elasticity might have increased in agriculture. As the proportion of purchased, flexible, operating inputs in the resource mix increases, opportunities become greater for adjusting output to price changes. More emphasis on cash, nonfarm produced resources makes farmers' short-run net returns more sensitive to price changes. Switching from slowly reproducible farm produced resources to nonfarm inputs with high production elasticity and input supply elasticity, is expected to increase the farm output supply elasticity. More education and emphasis on management increases farmers' awareness of the gains from optimum adjustments to price changes. Improved outlook information also might be expected to increase the supply elasticity.

There are, of course, forces which might depress supply elasticity. The gradual awareness by farmers of the cyclical nature of agricultural production (commodity cycles) may tend to reduce the short-run supply elasticity. Increased application of inputs, given the technology, moves agriculture farther up the aggregate output-input transformation curve, lowering production and supply elasticities. Finally, improved technology and increasing proportions of flexible inputs may raise the marginal response to a price change. But because the elasticity is computed at a larger output for any given price, the magnitude of the elasticity may remain unchanged or may decline. The supply elasticity is (dQ/dP) (P/Q), and if the decline in the ratio P/Q is more rapid because of improved technology than is the increase in marginal response dQ/dP, the supply elasticity will decline.

To determine if the supply response has increased, two methods are used. The first is to include separate price variables for (a) 1926 to 1941 and (b) 1946 to 1959 in a supply equation including other variables for the 1926 to 1959 period. If the estimated coefficients of the separate price variables are significantly different, the null hypothesis that the supply response or elasticity has not changed is rejected. The influences other than price are assumed to be homogeneous over the entire period. Some of these influences (e.g., S_p, T and T′) are quite highly correlated, especially over short periods. It is not considered feasible to estimate the individual effects of these variables in equations including less than 30 observations.

The second method for determining supply response through time is to include an interaction variable of price with time.[4] The interaction variable allows a gradual increase in the price coefficient through time, rather than a single shift as in the first method. The interaction of price with time or technology may be regarded broadly as a "real price." The fact that technology has improved leads to greater production for a given price.[5]

The variables in the supply functions are:

O = a dependent variable, measured as the production of crops and livestock on U.S. farms during the current calendar year for eventual human consumption; corrected for intermediate use of resources such as farm produced seed, feed and livestock, and farm produced power. It is expressed in millions of 1947-49 dollars.

Q_S = a dependent variable, measured as the quantity of farm products supplied to the markets during the current year. It includes current farm output and quantities sold from farm inventories of feed and livestock.

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[4] The least-squares equation for output estimated as a function of price, P, time, T, and other variables, X, is

$$\text{(a)} \qquad O = a + b\,P + c\,(TP) + d\,X.$$

After the form (a) is estimated, the equation may be written

$$\text{(b)} \qquad O = a + (b + cT)\,P + d\,X.$$

The coefficient (elasticity if O and P are in logarithms) of O with respect to P is b + cT and may either increase, decrease or remain constant through time, depending on the sign of c. If c is significant, the hypothesis is rejected that the coefficient of P has remained stable (has not changed at a linear rate) through time.

[5] The meaning of "real price" may be illustrated by a simple example. In competitive equilibrium with constant returns to scale, the input cost, XP_P, equals output returns, OP_R.

$$\text{(a)} \qquad OP_R = XP_P\,.$$

The expression may be written

$$\text{(b)} \qquad \frac{O}{X} = \frac{P_P}{P_R}\,.$$

It is apparent that a change in the output-input or productivity ratio O/X = T′ will lead to a new long-run equilibrium at a lower relative product price, commensurate with the increased efficiency. The output forthcoming for any price $O = f(P_R/P_P)$ approximately can be corrected for structural change by multiplying the price ratio by T′, thus

$$O = f\left(\frac{P_R}{P_P}\,T'\right).$$

$(P_R/P_P)_{t-1}$ = the past year index of the ratio of prices received by farmers for crops and livestock to prices paid by farmers for items used in production, including interest, taxes and wage rates. When the price variable is specified as 1926-41 or 1946-59, it is the actual observations in the period indicated but it has zero value for other years of the over-all period.

S_{pt} = the beginning year stock of productive farm assets, including real estate, machinery, feed, livestock and cash held for productive purposes in billions of 1947-49 dollars.

W_t = Stalling's weather index with 1958 and 1959 observations computed as deviations from a linear yield trend.

T' = an index of productivity, the ratio of farm output to all farm inputs in the current year. The variable is expressed as a percent of the 1947-49 average ratio of output to input.

T = time, an index composed of the last two digits of the current year.

The variables, measured as national aggregates, extend from 1926 to 1959, excluding 1942 through 1945. Modifications discussed earlier are introduced to allow estimation of the parameters of price for segments of the entire period.

Supply (Output) Function Estimated by Least Squares

Table 16.1 includes the coefficients, standard errors and other least-squares statistics for farm output, O, as a function of prices, productive assets and other variables. The equations are all estimated in linear form of original observations. The coefficient of each variable is highly significant and displays the anticipated sign in equation (16.2). A quantified measure of the direct influence of government policies, G, was included with the variables in (16.2) but the coefficient of G was not significant. The coefficient of current price variable $(P_R/P_P)_t$, included with the variables in equation (16.2); also was not significant. Thus statistics for $(P_R/P_P)_t$ and G are not included in Table 16.1. The productivity index T' is substituted for T and W in equation (16.3). Together, the three variables $(P_R/P_P)_{t-1}$, S_{pt} and T' explain 99 percent of the variation in O, and all coefficients are highly significant. The magnitude of the coefficient of S_p is considerably less, of price slightly less, than the comparable coefficients in equation (16.2). The degree of autocorrelation, indicated by d, is greater in (16.2) than in (16.3).

As one method of determining if the marginal response to price has changed, (16.2) and (16.3) are estimated with P_R/P_P divided into two subperiods. The resulting equations (16.4) and (16.5) provide conflicting estimates of the direction of change in the coefficient of price

Table 16.1. Supply Functions for Aggregate Farm Output, O, Estimated by Least Squares With U.S. Data From 1926 to 1959, Omitting 1942 to 1945; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation†	R^2	d‡	Constant	P_R/P_P t-1 (1926-59)	P_R/P_P t-1 (1926-41)	P_R/P_P t-1 (1946-59)	TP_R/P_P t-1 (1926-59)	S_P t	W t	T	T′	O t-1
(16.2)	.980	1.80	-19174	35.22 (12.58)				261.35 (44.20)	87.57 (13.61)	211.69 (38.16)		
(16.3)	.990	.94	-12710	31.95 (8.59)				123.17 (32.33)			258.99 (19.59)	
(16.4)	.980	1.79	-17929		28.43 (20.44)	32.81 (13.99)		254.68 (47.63)	88.71 (14.09)	202.78 (44.04)		
(16.5)	.990	.97	-13712		36.15 (13.13)	33.49 (9.43)		129.62 (36.09)			260.99 (20.45)	
(16.6)	.991	.94	-15109	49.48 (16.99)			-.420 (.352)	132.29 (32.98)			276.06 (24.14)	
(16.7)	.989	1.44	-7802		30.12 (13.53)	25.60 (9.59)					270.69 (21.17)	.223 (.077)

*Composition of the dependent variable, O, and of the indicated independent variables is discussed in the text.
†All equations are estimated linear in original values.
‡ The Durbin-Watson autocorrelation statistic d.

between the prewar and postwar periods. The null hypothesis that the coefficients are equal was not tested statistically but undoubtedly would not be rejected. Since the estimates of Table 16.1 are for original values only, they indicate the marginal response to price and not directly the elasticities. The elasticities computed for equations (16.4) and (16.5) are discussed later.

The variables in equation (16.6) allow the coefficient of price to change uniformly through time. The coefficient of TP_R/P_P is not significant for our specification, therefore we have no basis for rejecting the hypothesis that the coefficient of price has remained stable through time.

The coefficient of lagged output, O_{t-1}, was insignificant when included with the variables in (16.2) and (16.3). The interpretation is that there is no long-run adjustment, given the stock of productive assets and technology. An alternative formulation is that in the long run P_R/P_P determines S_p; this effect may be allowed by substituting lagged output for S_p in the supply function. The resulting equation (16.7) provides estimates of short-run price coefficients similar to those in (16.4) and (16.5). The estimated adjustment coefficient, .78, indicates that the movement, on aggregate resource adjustment, to the desired or equilibrium output is rapid. The adjustment of some resources such as operating inputs takes place in a short period according to earlier results, but adjustments of durable capital and labor were found to take place over a number of years. For this reason, we reject the distributed lag equation (16.7) as a suitable expression of long-run agricultural supply.

Elasticity of Supply (Output)

On the basis of the equations in Table 16.1 and the derived demand equations for agricultural inputs, the elasticity of farm output may be estimated over various periods of time. We first consider the short-run elasticity. The elasticity of output, O, with respect to $(P_R/P_P)_{t-1}$ computed from equations (16.2) and (16.3) at the 1926-59 mean is .12 and .10, respectively. The elasticities computed for the 1926-41 and 1946-59 subperiods at the means of these periods are both .10 according to equation (16.4). Computed from equation (16.5), the elasticity for the first subperiod is .13 and for the last subperiod is .10. These results do not provide support for the hypothesis that the aggregate short-run supply elasticity has increased between the two periods. They indicate a low supply elasticity for both earlier and later periods. Or stated otherwise, to the extent that income problems of agriculture stem from low short-run supply elasticity, the situation has not improved in recent decades.

The output elasticity may also be computed as the sum of the elasticities of demand for input X_i with respect to output price P_R multiplied by the respective elasticities of production with respect to X_i. (See equation (3.45).) This relationship is dynamic when we consider the input demand elasticities over various periods of time. Results in Chapter 14 indicate a demand elasticity for operating inputs with respect to product price of approximately .3 in the short run. The elasticity of durable assets, S_p, with respect to P_R was estimated to be approximately .04 in the short run in Chapter 12. If we are to accept the aggregate production functions in Chapter 4 and the demand functions in Chapters 12 and 14, we can make some further checks on output elasticity. From Chapter 4, the production elasticity for operating inputs is approximately .3, for durable capital is .6.[6] Hence, using the demand elasticities from Chapters 12 and 14 and the production elasticities from Chapter 4, the short-run elasticity of output is (.3) (.3) = .09 plus (.04) (.6) = .024, a total output elasticity of .114. This estimated short-run elasticity agrees closely with the estimates of equations (16.2) and (16.3). It must be noted, however, that the reliability of the production elasticity estimates is questionable. (Since the labor production elasticity is highly nonsignificant and probably is zero, it was not used in deriving supply elasticity.) Griliches' estimates of the short-run supply elasticity agree very closely with the above results.[7] Based on the foregoing statements, we conclude that a 10 percent drop in prices received by farmers likely has reduced aggregate farm output by approximately 1 percent in two years.

The intermediate- and long-run elasticity of farm output is found by substituting the investment function for S_p from Chapter 12 into the supply equation. Equations (16.2) and (16.3) indicate that a 1 percent decrease in S_p reduces farm output .95 and .46 percent, respectively. These estimates essentially are production elasticities, and the estimate .95 from equation (16.2) appears too large. An average of the estimates from equations (16.2) and (16.3), .7, agrees quite closely with the production elasticity based on the production functions in Chapter 4. Hence, the intermediate-run elasticities are based on equation (16.3) and on the average of the estimates from equations (16.2) and (16.3). The intermediate-run (approximately four years) elasticity of S_p with respect to P_R was found to be .07 in Chapter 12. The supply elasticity therefore is increased (.07) (.46) = .03 (equation 16.3) or (.07) (.7) = .05 (average of equations (16.2) and (16.3)) by the intermediate-run effect of S_p. The total intermediate-run elasticity is the short-run elasticity .10 plus the additional intermediate component due to S_p and is .13 to .15.

We also can use the demand elasticities derived in Chapters 10-14

[6] While S_p is not included directly in the production function of Chapter 4, the production elasticity of this variable is taken as the sum of that for real estate, machinery and livestock inputs. Since the elasticity for real estate is .4 or .5 and the elasticity for other durable assets is considered to be .1 or .2, the total is approximately .6. Because the production elasticity of Q_O is measured most accurately in Chapter 4 and the elasticity of S_p is approximately one minus this estimate, the elasticity of output with respect to S_p perhaps is more accurate than with respect to any one component of S_p (e.g. machinery, livestock and feed inventories, real estate, etc.).

[7] Griliches, op. cit.

and the production elasticities in Chapter 4 to estimate some intermediate-run supply elasticities. These should be looked upon largely as illustrations because of the uncertain validity of the estimated production elasticities. The intermediate-run supply elasticity is the component due to S_p or (.07) (.06) = .04, plus the component due to operating inputs, .09. The sum is .13 for the intermediate-run elasticity, with the component due to labor omitted since it is nearly zero. The operating input component also is omitted here because the response of these inputs to P_R (except through S_p) is zero after two years, according to the estimates in Chapter 13. It seems reasonable to conclude that the intermediate-run elasticity of output with respect to P_R is not much greater than .15. A sustained fall of 10 percent in prices received by farmers is expected to reduce aggregate output about 1.5 percent in four years.

The long-run elasticity of output with respect to prices received by farmers appears to be much greater. Based on the analysis in Chapter 12, the elasticity of S_p with respect to P_R is nearly unitary in the long run. Equation (16.3) indicates that the elasticity of O with respect to S_p is approximately .46; hence, the elasticity of output with respect to S_p can be estimated at (1.0) (.46), or .46. If the short-run elasticity is added, the total long-run elasticity with respect to P_R is between .5 and .6.[8] Based on the foregoing, a sustained 10 percent decrease in prices received by farmers might reduce farm output from 5 to 7 percent in the long run. The long run is more than 20 years away if the coefficient of adjustment for S_p is .10. It must be remembered that the computation of supply elasticities is a partial analysis, sizeable changes in output being possible due to other sources such as changes in technology. Thus, the supply elasticity of .5 to .6 may not be meaningful as a basis for projections because structural changes distort the long-term price influences. But the long-run supply elasticity is a useful indicator of the potential responsiveness of output to prices. The foregoing estimates of supply elasticity are subject to all the limitations of the data, techniques and models employed in this analysis, of course.

Shifts in Aggregate Supply (Output)

Farm output O increased over 70 percent from 1926 to 1959, or at an average compound rate of 1.71 percent per year. (See Figure 16.1.) The variables in equation (16.3) provide the basis for ascertaining two general sources of the increased output: (a) changes in the input level reflected in the variables P_R/P_P and S_p and (b) changes in the output with a given level of conventional inputs indicated by the variable T′. The output-input or productivity index indicates the change in output due to weather, management and efficiency. If T′ is at the 1959 value and

[8] The derived long-run supply elasticity computed from the production functions in Chapter 4 and the demand equations in Chapters 10 to 14 is (.3) (.3) = .09 (operating inputs) plus (1.0) (.6) = .6 (productive assets), or a total of .7.

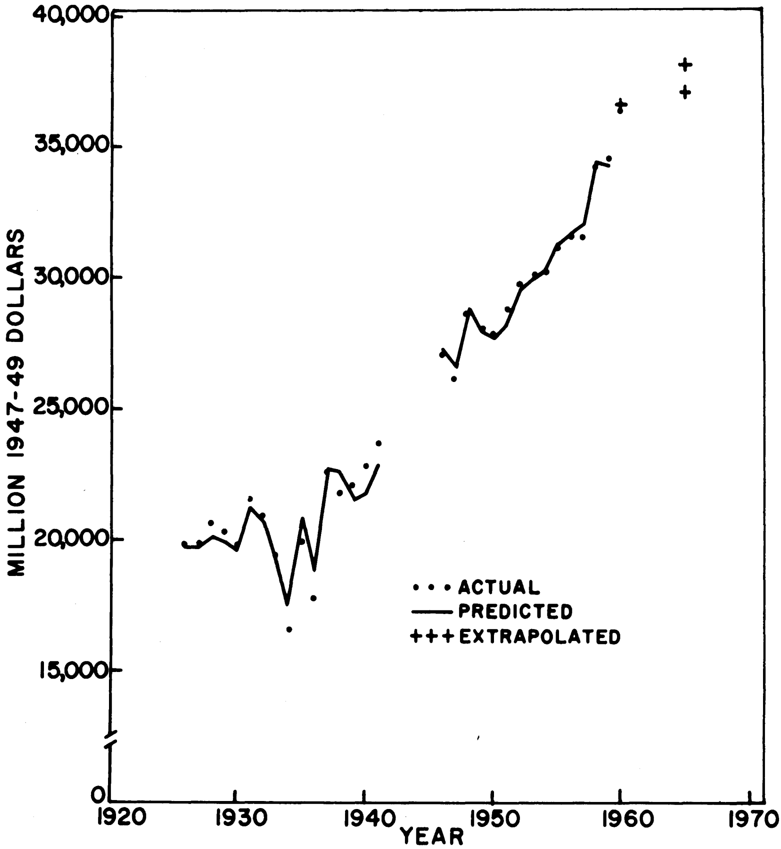

Figure 16.1. Trends in aggregate farm output O from 1926 to 1960 (predictions and projections from equation 16.3).

other variables are at the 1926 value, equation (16.3) indicates output would have been 61 percent greater than the predicted 1926 output. Of course we could predict the quantity directly. The productivity index increased from 75 in 1926 to 121 in 1959, a 61 percent increase. The equivalent results give credence to the estimational procedure. The implication is that the value aggregate of farm resource could have remained stable and farm output would have increased 61 percent or 1.45 percent per year due to changes in productivity.

Equation (16.3) suggests that output increased 16 percent from 1926 to 1959 due to investment in agriculture as indicated by S_p. If (16.2) were used to compute the portion of increased output imputed to S_p, the estimate would be higher. Equation (16.3) further indicates that output would have been 2 percent lower in 1926 if relative prices had been at 1959 levels, *ceteris paribus*. To summarize, the major portion of the increase in output from 1926 to 1959 is associated with increased productivity. Short-run price influences have had less relative effect on the secular increase in output.

It must be emphasized that the foregoing breakdown of sources of rising output primarily explain the aggregate resource movements in response to the direct price, P_R/P_P. It is not surprising that aggregate inputs increased only 6 percent from 1926 to 1959 since P_R/P_P decreased 12 percent. Ascribing the major portion of increased output to productivity hides many important resource substitutions. These substitutions are prompted by relative input prices (not reflected in the single-price variable P_R/P_P) and by improvements in relative quality, convenience and productivity of resources. To a considerable extent the rise in productivity associated with T' is caused by the substitution of more productive fertilizer, protein feed, hybrid seed, etc., for less productive farm produced labor, power, seed and feed. Resource movements and substitutions are a more important facet of rising productivity and output than the above discussion might lead one to believe. Substitutions are the result of long-run adjustments to both changing productivity and price ratios. More fundamental models to explain increasing output would include individual input price ratios in the supply equation. Problems of multicollinearity cause this degree of refinement to be impractical for our study, however.

Trends and Projections

Figure 16.1 illustrates graphically some of the economic and technological interpretations discussed earlier. The influence of weather is apparent from the low output in 1934 and 1936 and the high output in 1958, 1959 and 1960. If data for these years were corrected for weather, the trend in farm output would be considerably more uniform and would dramatize the short-run unresponsiveness of output to economic stimuli. The insensitivity of short-run supply response to price changes is demonstrated by the low response to falling prices in the early 1930's and in recent years. Despite the fact that relative farm prices P_R/P_P gradually declined in the past decade, and in 1960 were only 73 percent of the 1947-49 average, the increase in farm output was spectacular. The increased output is attributed to better weather, long-run price effects and to general changes in the production function reflecting improved technology and farming efficiency.

Equation (16.3) predicts quite well the changes in output. Figure 16.1 indicates that the prediction errors were considerably greater in the prewar than in the postwar period. The extrapolated estimate of 1960 output predicts the actual output very well. The prediction accuracy is misleading, however, since the actual index of productivity, T', for 1960 was known and used in the extrapolation. The error might have been large if an estimated value of T' had been used. The systematic component of T' is quite predictable, but the random component, due mainly to weather, can result in large prediction errors when T′ is unknown.

The level of output is projected to 1965 assuming prices will remain at the 1955-59 average level and that S_p will be 112.4 billion 1947-49 dollars by 1965. The estimate of S_p is based on equation (12.23) and is consistent with a USDA estimate.[9] T′ is assumed to continue increasing at the same average rate as in the 1926 to 1959 period. The lowest projected output is based on an extension of T′ for six years beginning with 1959. The second, higher estimate is based on an extension of T′ for five years beginning with 1960. The second estimate of T′, and consequently of output, is much greater because of the large increase in T′ from 1959 to 1960. The increase may represent the random influence of weather; hence, the lower estimate is included. The two results suggest 1965 output will be 4 and 7 percent above the 1960 predicted value.

The Market Supply (Output Less Change in Farm Inventories) Functions Estimated by Least Squares and Limited Information

Since the short-run market supply of farm products can be increased by depleting inventories of livestock and feed, its short-run elasticity is somewhat greater than output elasticity. In the long run the two measures of supply elasticity could be equivalent, depending on the future output sacrificed by depletion of current production stock. We are less concerned with the short-run inventory changes and give Q_S only a cursory examination. A single-market supply equation estimated by least squares with annual data from 1926 to 1959, excluding 1942 to 1945 is

$$(16.8) \quad Q_S = -16285 + \underset{(14.45)}{44.56}\,(P_R/P_P)_{t-1} + \underset{(50.79)}{331.91}\,S_{pt} + \underset{(44.51)}{173.13}\,T,$$

$$d = 1.08 \qquad R^2 = .97$$

where Q_S is the predicted supply quantity, including changes in inventories. (Standard errors are in parentheses.) The equation is linear in original values of variables defined earlier. The coefficients of current price, $(P_R/P_P)_t$, weather, W, and a measure of government programs, G, were not significant and were excluded from the equation. The coefficient of the weather variable was not significant because of the conflicting influences of weather on farm output and inventory components of Q_S. The elasticity of Q_S with respect to P_R/P_P is .15; with respect to S_p is 1.21 in (16.8). If the data except T are transformed to logarithms, the resulting equation is

[9] Johnson, Sherman. Agricultural outlook in the 1960's. (Multilith.) USDA. Agricultural Research Service. Washington. 1960.

(16.9) $$Q_S = 1.80 + \underset{(.050)}{.151} (P_R/P_P)_{t-1} + \underset{(.21)}{1.10} S_p + \underset{(.00086)}{.00344} T.$$

$$d = 1.17 \qquad R^2 = .96$$

Equations (16.8) and (16.9) are quite comparable, both indicating a short-run supply elasticity of .15. The coefficients of the variables in these equations are highly significant and the variables explain a high proportion of the annual variation in Q_S. The hypothesis that the residuals are not autocorrelated is rejected at the 95 percent level in (16.8) and is inconclusive in equation (16.9).

Because opportunities exist to adjust farm inventories and, hence, market supply in response to current changes in demand for farm products, it was considered advisable to estimate the supply function as part of an interdependent system. The assumption is that the current supply is determined jointly with the markets for farm inputs and farm output. The supply equation, estimated by limited information techniques with annual data from 1926 to 1959, omitting 1942 to 1945, is

(16.10) $$Q_S = 3100 - \underset{[-14.08]}{3427} P_{Ot} - \underset{[-5.41]}{1740} P_{Ht} + \underset{[5.15]}{1658} P_{Rt} - \underset{[-6.17]}{2548} N_t$$

$$+ \underset{[5.29]}{1448} S_{pt} + \underset{[.71]}{2132} G_t + 1740 T$$

where P_O is the price of operating inputs, P_H is the wage of hired farm labor, N is farm numbers and G is an index of government programs. Other variables are defined earlier in the chapter. Prices are deflated by the implicit price deflator of the Gross National Product. Elasticities are given in brackets below the coefficients; standard errors are not computed. All coefficients possess the anticipated signs, but the magnitudes appear too large. Because the elasticities are too large to be meaningful, we do not discuss the individual parameter estimates.

SUPPLY RESPONSE FOR CROPS AND LIVESTOCK COMPONENTS OF OUTPUT

The complications from substitutions among components of output are avoided by estimating the aggregate supply function in Table 16.1. The conclusion that the response of output to price has not increased in the postwar period does not preclude the existence of changing responses to price for components of output. In this section, a brief analysis of the supply functions of output, yield and production units for (a) crops and (b) livestock is presented to determine the sources of output elasticity (from changes in acreage and animal units or yield).

Total output, O, is equal to the number of production units, L, multiplied by the yield per unit, O/L. Tweeten and Heady show that the elasticity of O with respect to price, P, is equal to the elasticity of L with respect to P plus the elasticity of yield, O/L, with respect to P if yield is independent of L.[10] Knowledge of the response of production units and yield to price, therefore, helps to identify the source (change in yield or production units) and magnitude of the total supply elasticity. The assumption that yield is independent of acreage or livestock numbers is unrealistic, however. It is reasonable that crop yields diminish as cropland is extended to inferior lands in the short run. If prices fall, low producing cows or chickens are culled, increasing average production per remaining head. It follows that, in the short run, yield and the number of production units are inversely related. This short-run interdependence may be accommodated in a recursive model. The nature of the production process suggests that the "units" decision (how many acres or animals to use in production) is made before the "yield" decision. We assume that the current number of production units, L, is a function of past price, P_{t-1}, other variables, X_{t-1}, and an error, u_t, i.e.,

$$L_t = f(P_{t-1}, X_{t-1}, u). \tag{16.11}$$

Yield per production unit, O/L, is a function of the number of production units, current price, other variables, Y, and error, w, or

$$(O/L)_t = g(P_t, L'_t, Y_t, w_t). \tag{16.12}$$

To avoid least-squares bias (correlation between L_t and w_t), the predicted value of production units, L', from equation (16.11) is inserted in (16.12). This is equivalent to making L a predetermined rather than a current endogenous variable in the supply equation (16.12).

The variables used in these functions, not described earlier in this chapter, are:

O_{Crt} = the gross production of crops in the current year, expressed as a percent of the 1947-49 average crop output.

O_{Lkt} = the gross production of livestock in the current year, expressed as a percent of the 1947-49 average livestock output.

L_{dt} = land used for crops in the United States in the current year in millions of acres, including acreage from which one or more crops are harvested, plus acreage of crop failure and summer fallow. L'_d is the predicted values of L_d from a least-squares equation.

L_{kt} = the current number of animal units of breeding livestock in the United States, expressed as a percent of the 1947-49 average and excluding horses and mules. L'_k is the predicted L_k from a least-squares equation.

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[10] Tweeten, Luther G., and Heady, Earl O. Short-run corn supply and fertilizer demand functions based on production functions derived from experimental data; a statis analysis. Iowa Agr. Exp. Sta. Res. Bul. 507. June 1962. p. 577.

$(O/L)_{Ldt}$ = crop production per acre in the current year, expressed as a percent of the 1947-49 average.

$(O/L)_{Lkt}$ = livestock production per breeding unit in the current year, expressed as a percent of the 1947-49 average.

$(P_{Lk}/P_{Fd})_t$ = the current year index of the ratio of prices received by farmers for livestock to the price paid by farmers for feed, expressed as a percent of the 1947-49 average. When a subperiod such as 1926-41 is specified, the observations are actual values from 1926 to 1941, but zeros from 1946 to 1959.

All variables are for the United States from 1926 to 1959, excluding 1942 to 1945. Other variables are defined previously in the chapter.

Least-Squares Estimates of Crop Supply

Coefficients, standard errors and elasticities are indicated for crop output, O_{Cr}, as a function of past year prices, P_R/P_P, for two subperiods, the stock of productive assets, weather and time (Table 16.2). In (16.13) the coefficients of price are .20 for both periods and provide no basis for rejecting the null hypothesis that the response of crop output to prices has remained unchanged between the 1926-41 and 1946-59 periods. The results indicate that the short-run elasticity of crop output with respect to P_R or P_P is approximately .18.

Equation (16.14) would indicate that the marginal response of acreage to prices has increased at a linear rate since 1926. The coefficient of TP_R/P_P is significant and positive. Computed at the full-period mean of the price and time variables, the price elasticity of acreage is .055, indicating that acreage is relatively unresponsive to price changes. The long-run elasticity is the short-run elasticity divided by the adjustment coefficient .5 (1 minus the coefficient of L_{dt-1}). At twice the short-run elasticity, it is still of small magnitude.

The response of yield, $(O/L)_{Cr}$, indicated in equation (16.15), to price appears, under the particular specification, to have increased in the postwar period. The standard error of the difference between the coefficients of price for the two periods is .054. The difference in the coefficients is .051; hence, we have no basis for rejecting the hypothesis that the yield response to price in the two periods was equal. The elasticity of yield response to price is approximately .16 according to equation (16.15). The results indicate that the price elasticity of yield is approximately three times that of acreage (when elasticities are computed at the means of the entire period) but it is still a low quantity. The coefficient of the predicted current acreage, L'_{dt}, is negative and significant in (16.15) and suggests that greater acreage is associated with lower yields. Because of the current interaction between yield and acreage the elasticities of L_{dt} and $(O/L)_{Cr}$ with respect to price do not sum to the elasticity of crop output with respect to price. The

Table 16.2. Supply Functions for Crop Production, O_{Cr}, Cropland, L_d, and Crop Production per Acre, $(O/L)_{Cr}$, Estimated by Least Squares With U.S. Data From 1926 to 1959, Excluding 1942 to 1945*

Equation and Dependent Variable†	R^2	Constant	P_R/P_P t-1 (1926-59)	P_R/P_P t-1 (1926-41)	P_R/P_P t-1 (1946-59)	TP_R/P_P t-1	S_p t	W t	T	L_d t-1	L'_d t
(16.13) O_{Crt}											
Coefficient	.94	-48.32		.20	.20		.66	.438	.46		
Standard error				(.10)	(.07)		(.23)	(.037)	(.21)		
Elasticity				.19	.17						
(16.14) L_{dt}											
Coefficient	.77	252.48	-1.04			.030	.49		-3.10	.51	
Standard error			(.42)			(.010)	(.24)		(1.00)	(.13)	
Elasticity			.055 ‡			-- ‡					
(16.15) $(O/L)_{Crt}$											
Coefficient	.96	157.87		.156	.207		.55	.436	.35		-.50
Standard error				(.092)	(.065)		(.22)	(.066)	(.22)		(.16)
Elasticity				.150	.173						

*Composition of the variables is discussed in the text. The coefficient estimates in this and other tables may be somewhat biased by government programs reducing acreages and increasing yields and product prices.

†All equations are estimated linear in original values. Elasticities are computed at the mean of the 1926-59 period or the subperiod indicated at the top of the column.

‡The two coefficients of P_R/P_P are combined by assuming T is at the mean for the entire period. Hence, only one estimate of elasticity is obtained.

coefficient -.5 of L'_d indicates that a 1 percent decrease in current acreage is associated with a .12 percent increase in current yields. The result is an empirical manifestation of why acreage control programs have not been as effective as intended. If the coefficient is an accurate measure of short-run acreage-yield interaction, from 10 to 15 percent more acres must be removed from production to reduce crop output a given amount than would be necessary if acreage-yield interaction were zero.

The current price variable, $(P_R/P_P)_t$, was also included in the three equations in Table 16.2, but the coefficients were insignificant in all cases. The implication is that the effect of current year price is either too small to be detected by the small sample of observations or is overshadowed by the past year price. The prices received by farmers for crops and livestock rather than prices received for crops alone are included in the functions in Table 16.2 because many crops are grown for livestock feed. For these feed crops, livestock rather than crop prices are the relevant decision variable.

Least-Squares Estimates of Livestock Supply

Table 16.3 includes the coefficients, standard errors and price elasticities for least-squares equations expressing livestock output, O_{Lk}, animal units, L_k, and livestock output per animal unit, $(O/L)_{Lk}$. According to (16.16), the elasticity of O_{Lk} with respect to past year price is approximately .14. The current year price coefficient is not significantly different from zero. Equation (16.18) provides insufficient grounds for concluding that the marginal price response in the postwar and prewar periods differs. Collinearity is less apparent, standard errors smaller, and degrees of freedom greater in equation (16.17) than in (16.18). Thus, (16.17) provides the more reliable estimate of the price elasticity .19 of livestock numbers on farms. The adjustment coefficient .25 (one minus the coefficient of L_{kt-1}) indicates that the long-run elasticity is approximately four times larger than the short-run elasticity.

The marginal response of livestock yield (livestock output per animal unit) to price increased in the postwar period according to equation (16.19). The t test for the difference between the coefficients, .161 and .274, is highly significant. It is interesting to note that the price elasticities .22 and .26 for the respective prewar and postwar periods are rather similar, however. The elasticities are computed by multiplying the price coefficients by the price-yield ratio in the respective periods. Because of marked improvements in livestock production efficiency and for other reasons, the mean of yields is much larger in the postwar period. Since relative prices have not changed appreciably, the difference in elasticities is not large despite the significant shift in marginal response between the two periods.

The insignificant coefficient of L'_k in (16.19) is consistent with the

Table 16.3. Supply Functions for Livestock Production, O_{Lk}, Animal Units, L_k, and Livestock Production per Animal Unit, $(O/L)_{Lk}$, Estimated by Least Squares With U.S. Data From 1926 to 1959, Excluding 1942 to 1945*

Equation and Dependent Variable†	R^2	Constant	P_{Lk}/P_{Fd} t (1926-59)	P_{Lk}/P_{Fd} t (1926-41)	P_{Lk}/P_{Fd} t (1946-59)	P_{Lk}/P_{Fd} t-1 (1926-59)	P_{Lk}/P_{Fd} t-1 (1926-41)	P_{Lk}/P_{Fd} t-1 (1946-59)	S_p t	W t	T	L_k t-1	L'_k t
(16.16) O_{Lkt}													
Coefficient	.99	26.39	.022			.116			1.16	.024	.68		
Standard error			(.047)			(.041)			(.13)	(.048)	(.11)		
Elasticity			.0254			.135							
(16.17) L_{kt}													
Coefficient	.86	50.80				.165				-.081		.745	
Standard error						(.033)				(.037)		(.073)	
Elasticity						.188							
(16.18) L_{kt}													
Coefficient	.87	62.96					.140	.115		-.088		.59	
Standard error							(.038)	(.050)		(.037)		(.14)	
Elasticity							.177	.116					
(16.19) $(O/L)_{Lkt}$													
Coefficient	.99	16.08		.161	.274				1.060		.887		.029
Standard error				(.020)	(.032)				(.074)		(.069)		(.123)
Elasticity				.217	.255								

*Composition of the variables is discussed in the text.

†All equations are estimated linear in original values. Elasticities are computed at the mean of the 1926-59 period or the subperiod indicated at the top of the column.

hypothesis that there is no interaction between livestock numbers and output per animal. In another formulation, not included, the coefficient was significant and negative, however. The equations in Tables 16.2 and 16.3 are not intended to provide a definitive analysis of supply response but are intended to give a brief summary of the price response for two components of aggregate supply. The results are summarized as follows: The short-run price response for all components of output is low and highly inelastic. The livestock and crop components, and especially components within these aggregates, may be more responsive than aggregate output to prices because of opportunities for substituting crops for livestock and because much feed is fed to livestock. Only the response of cropland and of livestock output per animal unit to prices increased significantly in the period studied. Computed at the means, the price elasticity of cropland is lowest and of livestock yields is highest. Current prices have little influence on crop output and livestock inventories, but have a significant effect on current livestock yields.

ADJUSTING FARM OUTPUT

The estimates from this study provide a basis for appraising the implications of various policy instruments for adjusting demand and supply in agriculture. While much of the following discussion is oriented toward farm income, we do not select income adjustment as a unique goal or choose any one policy for attaining it. Many other means and ends might be specified such as parity farm income or prices, stable income, maximum farm or national income or free markets. The analysis here is predictive, basing expected effects on past behavior, and is subject to the limitations of data and specifications.

Before appraising the effectiveness of the price mechanism for bringing needed resource adjustment, it is necessary to examine trends in supply and demand shifters. If supply is shifting to the right at a much more rapid rate than demand, a supply elasticity greater than zero still may not make the price system an effective instrument for achieving needed adjustments.

The major shift variable of aggregate commodity supply is farm technology, T', and of demand is population. Additional sources of demand expansion such as increased disposable per capita income, foreign markets and improved diets have not resulted in large shifts in the demand curve and cannot be expected to do so in the future. It is interesting to note that the two major sources of demand and supply expansion — productivity and population — have shifted the respective curves at nearly equal annual average rates, 1.7 percent, during the postwar period (Table 16.4). The U.S. population increased 28 percent and agricultural productivity increased 27 percent from 1946 to 1960. If demand expands at the same rate as productivity, T', no change in the aggregate level of conventional resources would be necessary. It

Table 16.4. Percent Increase in Aggregate Demand and Supply Shifters in the Postwar Years

Item	Percent Increase		
	(1946-53)	(1953-60)	(1946-60)
Output	11.2	16.5	29.6
Input	4.0	-1.0	3.0
Productivity	7.1	18.9	27.3
National population	12.9	13.2	27.8

is not surprising, therefore, that the aggregate input in farming increased only 3 percent from 1946 to 1960.

While for the entire period supply has shifted at nearly the same rate as demand, the shift in supply appears to be accelerating (Table 16.4). National population increased 13 percent in each subperiod, but productivity increased 7.1 percent from 1926 to 1953 and 18.9 percent from 1913 to 1960. If, as in the latter period, demand and supply increase 1.8 percent and 2.5 percent per year respectively, product prices can be expected to decline, on the average, (2.5 - 1.8)4 = 2.8 percent per year (assuming the average price flexibility of demand is -4). Maintaining price at a constant level under these circumstances would require that annual output be restrained about .7 percent through resource reduction. A short-run supply elasticity of .1 suggests that output would decline only (.1)(2.8) = .28 percent in the short run from fewer inputs, or about half the needed adjustment to maintain prices. In the analysis which follows we assume that the magnitude of demand and supply shifters are equal since: (a) some additions to productivity are caused by "random" fluctuations in weather, (b) some potential future demand shifters such as increased national income are not included and (c) the analysis is simplified by abstracting from demand and supply shifters. It is well to caution, however, that this simplification tends to bias the results by overestimating the ability of the price mechanism to increase or maintain farm income.

Improvement in agricultural prices, income and return on resources can be achieved through demand expansion or supply contraction. We focus our attention only on feasible policy alternatives. National population and farm productivity T′ are not considered to be relevant policy instruments. Gains to society from greater productivity are too great to be disturbed by direct action; furthermore, the rate of productivity change is difficult to manage. Because the income elasticity of demand for farm products is low, and for other reasons, the potential for expanding the demand for agricultural products is limited. The onus of long-run agricultural adjustments falls logically on resource movements (and, consequently, output) in agriculture. The supply elasticity abstracts from the productivity index and is an indication of the output response to prices received, P_R, through resource adjustments.[11]

We first consider the implication of free markets for adjusting output, prices and income in agriculture. Some studies of this type have been made but have lacked adequate knowledge of the supply response.[12] A study of the ramifications of free markets is a major research project in itself. The principal purpose of this study is to estimate supply parameters rather than to trace the exact implication of free markets. But to illustrate the meaning of the supply elasticities found in this study and to illustrate broadly some of the adjustments that would occur, a free market model is simulated using elements of the existing situation. The assumptions of the model are: (a) current agricultural output is predetermined by past prices (supply), and current price is determined by current output (demand), (b) the average price flexibility of product demand for domestic and foreign markets in the short run at the farm level is -4.0 (price elasticity is -.25)[13], (c) that 5 to 10 percent of all agricultural output is being diverted from price-setting markets by government accumulation of surplus output, export and consumer subsidies or resource restrictions,[14] (d) that nonprice influences shifting supply to the right are offset by demand expansion, (e) that input prices in aggregate will remain stable, that existing stocks will not be

[11] The assumption is that the aggregate output-input ratio in agriculture is unaffected by prices received, P_R. To test this hypothesis, the productivity index, T′, was regressed on relative prices, P_R/P_P, in agriculture. No significant relationship could be found, and the hypothesis was not rejected. This test does not preclude the possibility of sensitivity of T′ to changes in the relative input prices, e.g. ratios of farm labor wages to machinery price or operating input price.

[12] Brandow, G. E. Interrelations among demands for farm products and implications for control of market supply. Pa. Agr. Exp. Sta. Bul. 680. University Park. 1961; (Shepherd, Geoffrey, Paulsen, Arnold, Kutish, Francis, Kaldor, Don, Heifner, Richard, and Futrell, Gene.) Product, price and income estimates and projections for the feed livestock economy under specific control and market-clearing conditions. Iowa Agr. and Home Econ. Exp. Sta. Special Report 27. Ames. 1960; USDA. Projections of production and prices for farm products for 1960-65 according to specified assumptions. In U.S. Congress. Senate. Report from the USDA on farm price and income projections. [Ellender Report] 86th Congress, 2nd Session, Senate Document 77. pp. 3-24. U.S. Government Printing Office. Washington. 1960.

[13] A recursive model is assumed in Table 16.5. The model is equivalent to assuming that the current supply quantity (output) is a function of past prices in the supply equation linear-in logarithms. Similarly, the current price is a function of the predetermined current quantity in a single least-squares product demand equation linear in logarithms. The coefficient of the quantity variable in the demand equation is the constant price flexibility. It is not strictly correct to assume that the inverse is the price elasticity of demand. That is, the price flexibility generally is defined as the coefficient of quantity when price is the dependent variable. Price elasticity of demand generally is defined as the coefficient of price when quantity is the dependent variable. The two concepts are equivalent only if there is no error in the model or if the assumptions are correct underlying the limited information technique, which is independent of the direction of normalization. The product demand function was not estimated in this study. For a summary of several estimates of the price elasticity of demand for product aggregates in agriculture, see Brandow, op. cit., pp. 19, 50.

[14] Cf. Shepherd, et al., op. cit., p. 6; Shepherd, Geoffrey, Appraisal of the federal feed-grains programs. Iowa Agr. Sta. Res. Bul. 501. Ames. 1962. p. 359; USDA. Projections of production and prices, op. cit., p. 20.

placed on the market,[15] that prices will be determined by current output and (f) that markets for farm products (outside of government restrictions, etc.) are now in equilibrium. The estimated elasticity of aggregate supply (output) is .10 in the short run, .15 in the intermediate run. There would be obvious advantages in considering the output responses for several categories of farm output. For purposes of this study, however, it is felt that many of these advantages would be lost because of the elusive substitution possibilities among components of farm output.

The movements of farm prices, output and income are indicated in Table 16.5. The first example is based on the assumption that the government would remove farm restrictions and subsidies until farm product marketings are 5 percent above the initial level in year 1. The 5 percent increase in output decreases farm prices from the initial index of 100 to 80 in year 1, or 20 percent. Because output is greater, gross income falls by a smaller percentage, 16 percent.

Table 16.5. Simulated Adjustments of Farm Output, Price and Income to Free Markets Based on Structural Elasticities Estimated in This Study

	Year				
	0	1	2	3	4
Cumulative adjustments (percent of initial year)					
Example 1 — 5 percent increase in output					
Output, O	100.0	105.0	102.9	102.6	102.4
Prices received, P_R	100.0	80.0	88.4	89.6	90.4
Gross income	100.0	84.0	91.0	91.9	92.6
Net income:					
(a) Above operating expenses*	100.0	74.2	88.5	90.7	92.3
(b) Above production expenses†	100.0	58.4	82.1	85.7	88.3
Example 2 — 10 percent increase in output‡					
Output, O	100.0	110.0	105.6	104.9	104.5
Price, P_R	100.0	60.0	77.6	80.4	82.0
Gross income	100.0	66.0	81.9	84.3	85.7
Cumulative elasticities					
With respect to P_R					
Demand for Q_O §	0	0	.3	.4	.5
Demand for Q_H +	0	0	.1	.2	.3
Supply of O #	0	0	.10	.13	.15
With respect to Y_F					
Demand for S_p **	0	0	.02	.03	.04
Demand for Q_F ††	0	0	.1	.2	.3

*Gross income less current operating and hired-labor expenses. The indices depend on the absolute level and relationship between expenses and income — those used for the initial period are based on average actual 1958-60 relationships. The assumed price flexibility of demand -4 and other assumptions are given in the text — the excess output is assumed to be placed on the market in year 1.

†Gross income less operating and hired-labor expense; also less taxes, interest, rents and consumption of farm capital. The latter expenses are assumed to be proportional to the stock of assets, S_p.

‡Only a few quantities are presented because the estimated elasticities are not considered applicable for large adjustments.

§Based on demand functions for operating inputs, Q_O, estimated in Chapter 13. These and other elasticities assume current quantities respond to past and other prior prices.

+From demand functions for hired farm labor, Q_H, estimated in Chapter 8.

#Output supply elasticity, estimated earlier in this chapter from equations in Table 16.1.

**Based on investment functions for all productive assets, S_p, estimated in Chapter 12. Y_F is net farm income.

††Based on functions for family labor, Q_F, in Chapter 9.

[15]Surplus stocks might be liquidated through Public Law 480 and other federal measures to remove stocks outside regular market channels.

Assuming expenses remain at current levels, net income (a) above operating expenses would fall about 25 percent and (b) above production expenses would fall over 40 percent in year 1. The supply response to low prices in year 1 becomes apparent in year 2. For each 10 percent drop in prices, farmers decrease output 1 percent. Hence, output falls from 105 in year 1 to 103 in year 2. The reduction of output and expenses in year 2 arises primarily from the reduction in operating inputs such as fertilizer, protein feed, etc. After year 2, supply adjustments depend primarily on adjustments in durable inputs. The potential long-run adjustment of output is large from durable inputs such as irrigation equipment, drainage and livestock inventories (the long-run price elasticity is .6). The annual or "marginal" adjustment is small, however, and is only .03 from year 2 to year 3. Since P_R is 88.4 in year 2, or 11.6 percent below the initial price, the output adjustment is (11.6) (.03), or .3. Output in year 3 is therefore 102.9 - .3 = 102.6. The "excess" supply is 2.6 percent, hence, P_R is (4) (2.6), or 10.4 per cent below the equilibrium or initial price in year 3 according to the assumptions in example 1. Gross income is (102.6) (89.6) or an index of 91.9 in year 3.

Both measures of net income also are improved, not only because gross income is higher, but also because expenses are lower in year 3. Net incomes above operating expenses and production expenses respectively are 92 and 88 percent of initial levels by year 4. The impact of declining product prices is greater for net income over production expenses because interest on mortgages, taxes and depreciation are nearly fixed costs. It is apparent that the rate of adjustment of prices, output and income toward initial levels is slowing considerably by year 4. Although prices and incomes remain considerably below initial levels, they are improving gradually. Adjustments become small, and our estimates become even less accurate; therefore the adjustments after year 4 are not illustrated.

Complete withdrawal of government restrictions and export subsidies would be expected to increase by 5 to 10 percent the quantity of farm products entering price-setting markets. Example 2 in Table 16.5 suggests the price, output and income response if the upper limit, 10 percent (of additional output) is reached. The 10 percent rise in output in year 1 depresses farm prices 40 percent and gross income 34 percent. Farm inputs have not yet responded to falling prices, and production expenses remain at the initial level in year 1 according to the assumptions of the model. Actual farm expenses currently are 65 to 70 percent of realized gross farm income. A drop of one-third in gross farm income, depicted in year 1 of example 2, would leave the average farm operator with little net income. Because net income is required for household and other expenditures, a serious farm financial crisis would result. The prices and income would be improved somewhat after several years, but price and gross income are only 82 and 86 percent, respectively, of the initial level by year 4. Example 2 is not considered realistic; the actual increase in farm marketings with free markets is expected to be around 6 or 7 percent, hence closer to example 1. If government influence in agriculture continues to grow, example 2 may become a more realistic setting, however, and points up the increasing difficulty of a government exit from agriculture as the surplus capacity grows.

Table 16.5 illustrates (a) the adjustment to free markets and (b) the interpretation of the parameters estimated in this study. The recursive nature of the adjustment process is apparent. It is not possible to conclude because the intermediate run elasticity is .15 that a 40 percent drop in P_R (from an index of 100 to 60 in example 2) will decrease output (40) (.15) = 6 percent in four years. To decrease output 6 percent, the 40 percent fall in price must be sustained each year. Because some adjustment occurred before year 4, P_R was above the year 1 index in years 2 and 3 (was less than 40 percent below the initial level). Thus, output declined to an index of 104.5 rather than to 103.4 (110 less 6 percent of 110) in example 2. These results caution that the supply elasticity may be a misleading indication of adjustment potential. Supply elasticity estimates indicate that output is decreased 6 percent in approximately 25 years by a sustained 10 percent drop in P_R. But because of the recursive nature of adjustments, indicated in Table 16.5, the initial drop in price is not sustained, but gradually rises. The result is that less adjustment is made in a given period than the supply elasticity, defined in terms of a once-for-all price change, might lead one to expect.

The benefits of a supply response greater than zero are apparent from Table 16.5. If the elasticity of supply were zero, the indices of price and income would fall to 60 and 66, respectively, in example 2 and remain at that level each year thereafter. The fact that gross income recovered nearly 30 percent from year 1 to year 4 in example 2 indicates that supply response cannot be omitted in studies of free markets without introducing large errors.

For net income above production costs per family worker to be improved, the number of workers would need to decline approximately 12 percent in example 1. In Chapter 9 a sustained 10 percent fall in relative (residual) farm income per worker was found to reduce the number of workers up to 3.5 percent in four to six years. Assuming optimistically that national employment is very high and that the elasticity of response of labor to income is .30 in four years (see Chapter 9), the decline in labor numbers is 7 percent by year 4. Thus, the fact that net income has fallen 12 percent, employment only 7 percent, suggests that per worker incomes would be considerably below initial levels by year 4. Over a longer period, income per worker would continue to improve but at a very slow rate. The example is crude, of course, and is only a very rough measure of the possible effect of free markets on per worker incomes. Like other estimates in this section, the results suggest aggregate effects, and the micro impact for individuals may run counter to the total.

One may question whether the results in Table 16.5 underestimate or overestimate the impact of free prices on incomes in agriculture. Based on the previous results, the assumption that nonprice influences shifting supply to the right will be offset by demand expansion does not seem realistic. *Rapid recent increases in farming efficiency indicate that source T' alone may exceed the expanding demand without increasing* the application of conventional inputs. Restraining the level of conventional inputs places a great strain on the price system. The input demand functions estimated in this study suggest that there are strong nonprice influences (at the farm level, but not in the national economic growth framework) which increase inputs with high production elasticities. These influences which change the over-all production function and the marginal productivity of individual resources, discussed in the foregoing chapters, are likely to continue in the future and in many instances to overshadow the "direct" price effects. Even drastic reductions in farm product prices may be unable to offset the input-increasing effects of these forces. Hence, the estimates of Table 16.5 probably present an overly optimistic view of the ability of the price system to cope with the resource and income adjustments needed in agriculture.[16]

Some implications of "direct" supports for farm prices P_R without controls or diversionary purchases are apparent from the estimated supply elasticity. By "direct" price support, we refer to an amount per unit paid by government to producers and announced prior to the production period. The output, after production, is sold in the market. This is only one, and not necessarily the most efficient or desirable, type of price support. We use it only for illustration of the recursive interrelationship of price and output reactions.

The output-increasing effect of direct price supports acts, without control of supply, against the intended purpose. Assume that direct price supports, paid per unit produced, increase P_R 10 percent. Since the short-run supply elasticity is .10, output is expected to increase by 1 percent in two years. If price flexibility is -4.0, the 1 percent increase in output is expected to decrease P_R by 4 percent. Hence, the net "real" support price is the original 10 percent increase minus 4 percent, or 6 percent. In the intermediate run, the supply elasticity is .15; hence, output should be 1.5 percent greater. The net real increase in P_R would be only 4 percent. It is apparent that because of the inelastic demand for farm products, the intended price and income benefits to farmers would, through this system of direct supports, soon be dissipated unless farm output was to be controlled.

[16]Another source of declining net income and need for resource adjustment is the increasing prices paid by farmers for inputs. Prices of some resources (e.g. labor) increase more than others (e.g. operating inputs), but the general price trend is upward. From 1946 to 1960, prices paid by farmers for items used in production, including interest, taxes and wage rates, increased 44 percent. Rising input prices like falling output prices depress net farm income and place an additional burden on the price mechanism to bring needed adjustments.