12.

Investment in Plant and Equipment

THIS CHAPTER is an extension of the methodology in Chapter 10 and parallels the empirical applications in Chapter 11. It is an analysis of aggregate capital categories. In this monograph, capital is divided into two broad categories: (1) operating or working capital, and (2) durable or fixed capital. Both include heterogeneous types of resources. While the individual types of resources often are quite "unlike" in respect to their function in the production process and the products for which they are used, we wish to examine whether some "over-all" aspects of capital investment behavior can be explained for the U.S. farm industry. One purpose in analyzing aggregate investment is to explain the stock of productive assets in relation to: (a) the demand for other resources such as operating inputs and (b) the supply of agricultural output. We also wish to evaluate the response of investment in the agricultural plant to price changes and technical trends.

From a broad policy standpoint, problems of underemployment, low returns and pressures for labor movements from rural areas are associated with the laborsaving and output-increasing investment process in agriculture. Policies to deal with these problems cannot be devised intelligently without knowledge of the effect of programs on the agricultural investment process. Some policies to raise labor income may increase investment and output sufficiently to reduce product prices and thus mitigate the intended benefits in the long run. The problems are quite different in underdeveloped areas where investment does not occur rapidly enough, but the same type of information about the investment parameters can be useful in devising strategies to stimulate capital formation.

Least-squares estimates are used for estimating demand functions for two aggregate categories of farm investment. The first major category of aggregate investment examined in this chapter includes farm buildings and improvements and all farm machinery. This investment aggregate is analyzed separately because it often is referred to as "investment in agricultural plant and equipment." However, as a separate category, it preserves some properties of homogeneity by excluding human, livestock and feed components of investment. The analysis also is of methodological interest for the analyses of all productive assets to follow and contributes some useful hypotheses on the elasticities, depreciation rates and other empirical quantities of building improvements and farm machinery. The second aggregate category of agricultural investment to be examined includes all farm machinery, real estate, livestock, feed and cash held for productive purposes. While there would be advantages in excluding land and including only real estate improvements, difficulties in separating the two components prompted inclusion of the total stock of real estate.

INVESTMENT IN BUILDING IMPROVEMENTS AND ALL FARM MACHINERY

The general logic of the model employed was discussed in detail in the previous chapters. Annual net or gross investment is considered to be a function of prices, technology, weather, government programs, external and internal financing capabilities, the interest rate, capital gains and weather. Expectations are undoubtedly important in explaining year-to-year investment in the farm plant. The profitability and ability to pay for a durable asset depends on future prices, technology, weather, and other quantities which change with time. Risk and uncertainty theory suggests that farmers base future expectations on past realities. Hence it appears desirable to include past values of prices and other variables in the investment function. Even if the data were available, it is necessary to reduce the number of expectation and other explanatory variables in the model because of multicollinearity and the limitations of least-squares statistical techniques. The analysis is restricted to those few variables previously found most significant in explaining investment behavior for farm assets, and such additional variables as deemed appropriate for specific investment functions.

Past net farm income concisely represents several expectation influences that are essential elements of the investment function. Since net income may be either invested in productive assets or spent for household items, the variable introduces concepts associated with the firm-household complex. The marginal propensity to invest and to consume may be regarded as a manifestation of the preference or indifference function of the farmer, and perhaps as important, of his wife. At times the distinction between the firm or production sector and the household or consumption sector is not clear. This is especially apparent for farm autos, but is more subtle for farm tractors. Undoubtedly, many tractors add more to farm costs than returns even in the long run. These uneconomic purchases of a "productive" asset might very well be classified as consumption expenditures because the purchase is similar to expenditures for household appliances providing comfort and convenience. These considerations do not necessarily lead to a different specification of the investment function, but suggest caution in interpretation of the coefficients as "marginal propensities to invest in productive assets."

Since expectations and adjustments are important features of the investment process in agriculture, it is desirable to combine adjustment models such as G, I and J with the expectation models B or C from Chapter 10. A more accurate estimate of stock than of annual gross investment is available for all productive assets; hence, models I and J are useful. These models are based on the assumption that farmers adjust gradually to the equilibrium level of stock on the basis of expected income, prices and other variables. The dependent variable is net investment (first differences of total stock) and is a sensitive measure of investment behavior. In addition, models I and J are more amenable to estimation of the elasticities of stock with respect to income and prices than are models with gross annual purchases as the dependent variable.

Time series of both gross and net investment in building improvements and machinery are available. Hence, functions are derived using each as the dependent variable. This procedure provides a test of the comparability of two models and preliminary knowledge on net investment in all productive assets. Equations are estimated in original value only because net investment is sometimes negative and not suited for logarithm transformation. Net investment is a first difference; consequently, an additional first difference transformation is not appropriate.

The Variables

The variables specified in the investment function are defined as follows:

Q_{It} = a dependent variable, national aggregate expenditure on building improvements (including fences, windmills, wells and dwellings not occupied by the farm operator), motor vehicles (40 percent of automobile purchases) and other farm machinery and equipment. The variable is intended to measure the productive portion of purchases in millions of 1947-49 dollars. Components of the series are weighted by 1935-39 prices prior to 1940 and 1947-49 prices after 1940.

S_{It} = the stock of farm buildings and all farm machinery on farms on January 1 of the current year in millions of 1947-49 dollars.

ΔS_{It} = a dependent variable to represent the change in investment stock during the current year, i.e. $S_{It+1} - S_{It}$, measured in millions of 1947-49 dollars.

$(P_I/P_R)_t$ = the current year index of the ratio of the price of all farm machinery and building materials to prices received by farmers for crops and livestock; 1947-49 = 100.

Table 12.1. Annual Gross Investment in All Farm Machinery and Building Improvements Q_I Estimated by Least Squares With Annual Data From 1926 to 1959, Omitting 1942 to 1947; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation and Model †	R^2	d‡	Constant	P_I/P_R t	Y_F t-1	Y_F t-2	Y_{DF} t-1	Y_{AF} t-1	E t-1	T	Q_I t-1	S_I t
(12.1) B	.984	1.55	888	-11.65 (1.19)					1.74 (.19)	38.00 (5.62)		
(12.2) A	.959	1.09	-348	-11.54 (2.15)	.117 (.027)					63.10 (6.27)		
(12.3) A	.973	1.04	-455	-10.79 (1.78)	.063 (.027)	.072 (.020)				58.62 (5.31)		
(12.4) C	.977	1.06	-467	-10.74 (1.50)			.142 (.019)			56.91 (4.72)		
(12.5) D	.983	1.24	-227	-11.78 (1.19)				.135 (.015)		55.07 (4.09)		
(12.6) BF	.986	1.60	786	-10.23 (1.33)					1.33 (.27)	33.05 (5.87)	.188 (.095)	
(12.7) F	.976	1.39	93	-8.66 (1.82)	.054 (.026)					39.92 (7.55)	.41 (.10)	
(12.8) G	.960	1.17	-492	-10.94 (2.28)	.123 (.028)					55.88 (10.73)		.017 (.021)

*Sources and composition of the dependent variable Q_I and the indicated independent variables are discussed in the text.
†Estimated only from original observations. Adjustment and expectation models are presented in Chapter 10.
‡The Durbin-Watson autocorrelation statistic d.

E_{t-1} = the past year ratio of proprietors' equities to total liabilities in agriculture.

Y_{Ft} = the net income of farm operators from farming during the current year, deflated by the index of prices paid by farmers for items used in production, including interest, taxes and wage rates. Net income includes cash receipts, government payments and nonmoney income less production expenses in millions of 1947-49 dollars. Lagged values of income are also specified in the investment function.

Y_{DFt-1} = the declining three year arithmetic average of Y_F. Past year income t-1 is weighted by .50, the previous year t-2 by .33 and the year t-3 by .17.

Y_{AFt-1} = the simple past four year arithmetic average of Y_F.

Y_{WFt-1} = the increasing arithmetic average of Y_F. Y_{Ft-2} is weighted by .16, Y_{Ft-3} by .33 and Y_{Ft-4} by .50.

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

All variables in Tables 12.1 and 12.2 are annual data for the United States from 1926 to 1941 and 1948 to 1959. In Table 12.3, variables extend from 1913 to 1959, omitting 1942 to 1947 in selected equations for comparison with the results of equations fitted to data for 1926 and later years.

In addition to the variables indicated, the price of operating inputs, P_O, the hired farm wage rate, P_H, and the price of all farm inputs, P_P, individually were initially specified in the investment function. However, since the coefficients of the variables were not significantly different from zero, they were dropped from equations presented. The influence of operating input and other related input prices perhaps is best expressed in the net farm income variable. Equations were specified including farm size, the short-term interest rate and a measure of return on investment in common industrial stock, but the coefficient of each of these variables also was not significant and the corresponding equations are not included.

Gross Annual Investment

Current price, net income, the equity ratio and time explain a large proportion of the annual variation in gross annual investment according to the results in Table 12.1. The coefficients of P_I/P_R, E and T are highly significant in equation (12.1), and the coefficient of determination between Q_I and the three variables is .98. The Durbin-Watson statistic (d = 1.55) does not lead to rejecting the hypothesis that the residuals are uncorrelated at the 95 percent probability level. Interpreting E as representing the combined effects on investment of farm income, capital

Table 12.2. Annual Net Investment in All Farm Machinery and Building Improvements ΔS_I Estimated by Least Squares With Annual Data From 1926 to 1959, Omitting 1942 to 1947; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation and Model †	R^2	d‡	Constant	P_I/P_R t	Y_F t-1	Y_F t-2	Y_{DF} t-1	Y_{AF} t-1	E t-1	T	S_I t
(12.10) BI	.944	1.35	1297	-10.28					1.34	37.85	-.113
				(1.35)					(.21)	(8.20)	(.014)
(12.11) AI	.924	1.10	189	-9.36	.049	.056				48.98	-.100
				(1.90)	(.028)	(.021)				(8.97)	(.017)
(12.12) CI	.932	1.16	196	-9.38			.110			48.52	-.102
				(1.63)			(.020)			(8.05)	(.016)
(12.13) DI	.944	1.30	429	-10.35				.107		50.46	-.111
				(1.34)				(.017)		(6.97)	(.014)

*Sources and composition of the dependent variable ΔS_I and the indicated independent variables are discussed in the text.

†Estimated only in original observations. Adjustment and expectation models are presented in Chapter 10.

‡The Durbin-Watson autocorrelation statistic d.

gains and financial position (reflecting both the willingness of farmers to invest and also the willingness of external sources to lend funds), equation (12.1) might be taken as a simple but meaningful expression of the investment process.

Equations (12.2) to (12.5) are included to express more clearly the role of net income in investment. As additional lags are introduced, the value of R^2 increases. The sum of the income coefficients in equations (12.2), (12.3) and (12.4) increases from .117 to .135 to .142 as additional lags are added. It appears that the marginal propensity to invest (income coefficient) would be increased very little by additional income lags. The four year simple arithmetic average income in equation (12.5) increases the R^2 slightly, but the marginal propensity to invest is slightly less. Originally, the equation was estimated with the Ladd-Tedford model D (see Chapter 10), but the coefficient of the weighted income variable $Y_{WF_{t-1}}$ was not significant and it was dropped from the equation.

The coefficient (1-g) of the lagged annual gross investment $Q_{I_{t-1}}$ is significantly greater than zero in equation (12.7) and would indicate that the adjustment coefficient may be less than 1. However, equation (12.6) provides a different result, indicating an adjustment coefficient near unity. If we accept (12.6), it appears that if farmers and external credit sources are satisfied with the current financial and price structure and expectation of future earnings, little time is required to adjust to the equilibrium level of annual purchases. However, while little time might be required to adjust to the desired level of annual investment, the time required to adjust to the equilibrium level of capital stock may be long. Model G (equation 12.8), included to determine the nature of the long-run adjustment to equilibrium stock, indicates that the adjustment and depreciation coefficients are of equal magnitude. Since the coefficient of lagged stock, h-g, does not differ statistically from zero, the implication is that the adjustment and depreciation rates are equal. If the depreciation rate is .10, the adjustment rate also is approximately .10.

Table 12.3. Annual Net Investment in All Farm Machinery and Building Improvements ΔS_I With Current Net Income Substituted for the Current Price Variable Used in Table 12.2; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included for Least-Squares Estimates From Annual Data*

Equation, Time Period and Model†	R^2	d‡	Constant	Y_F t	Y_F t-1	Y_F t-2	Y_{DF} t-1	Y_{AF} t-1	Y_{WF} t-1	E t-1	T	S_I t
(12.14) (1926-59)	.909	1.70	-686	.130						1.30	-4.53	-.054
BI				(.025)						(.29)	(8.82)	(.019)
(12.15) (1926-59)	.912	1.34	-1635	.116	.082	.032					8.88	-.046
AI				(.027)	(.027)	(.024)					(8.45)	(.018)
(1913-59)	.756	1.98	-1474	.122	.057	.030					6.54	-.038
				(.029)	(.032)	(.027)					(5.35)	(.020)
(12.16) (1926-59)	.917	1.42	-1607	.119			.113				8.25	-.048
CI				(.025)			(.023)				(8.05)	(.018)
(1913-59)	.775	2.06	-1474	.119			.097				6.68	-.043
				(.026)			(.027)				(5.06)	(.019)
(12.17) (1926-59)	.918	1.51	-1582	.120				.188	-.074		7.81	-.050
DI				(.025)				(.072)	(.061)		(8.17)	(.018)
(1913-59)	.801	2.35	-1454	.131				.065	.035		6.96	-.055
				(.026)				(.079)	(.067)		(4.82)	(.019)
(12.18) (1926-59)	.913	1.71	-1546	.131				.104			7.01	-.052
DI				(.024)				(.022)			(8.24)	(.018)
(1913-59)	.800	2.29	-1458	.125				.105			6.97	-.053
				(.022)				(.024)			(4.78)	(.019)

*Sources and composition of the dependent variable ΔS_I and the indicated independent variables are discussed in the text.

†Estimated only from original observations. Adjustment and expectation models are presented in Chapter 10. Observations for 1942 to 1947 are omitted in both periods.

‡The Durbin-Watson autocorrelation statistic d.

On the basis of the equations in Table 12.1 it appears that annual investment Q_I can be expressed adequately without lagged annual investment or stock. It is interesting to note that the long-run coefficients in equation (12.6), found by dividing the short-run coefficients by the adjustment coefficient .81, is -12.6 for $(P_I/P_R)_t$ and is 1.64 for E_{t-1}. The similarity of these coefficients to the respective estimates -11.65 and 1.74 in equation (12.1) implies that the error introduced into estimates of short-run or long-run elasticities from ignoring the adjustment (through Q_{It-1}) of gross annual investment to equilibrium is small.

Net Annual Investment

Net investment is the dependent variable for the equations in Table 12.2. The relationship between net investment ΔS_{It} and gross investment Q_{It} is expressed in the identity (12.9), where h is the annual rate of depreciation. Gross investment necessarily is positive, but if $Q_{It} < hS_{It}$, net investment is negative.

(12.9) $$\Delta S_{It} = Q_{It} - hS_{It}$$

If the annual depreciation allowance were nearly constant and small, use of either gross or net investment as the dependent variable would result in similar coefficients. Q_{It} and S_{It} both are increasing functions of time, and subtraction of the replacement or depreciation allowance from Q_{It} tends to reduce the absolute magnitudes of the coefficients as compared to those estimated for Q_{It} alone.[1] The coefficients are smaller in Table 12.2 than in Table 12.1 for this reason. (An adjustment is made in the coefficients to insure comparability of elasticity estimates in subsequent analysis.)

Aside from the fact that the R^2's are lower in Table 12.2 than in Table 12.1, the coefficients are quite similar, as they are expected to be, given the relationship between ΔS_{It} and Q_{It} in (12.9). This similarity is preserved although the dependent variable ΔS_I is the first difference of a stock variable based on somewhat dubious data. Because of initial errors and additional errors introduced in construction of the stock data, changes in the depreciation rate h, etc., the identity in (12.9) is not entirely satisfied by available data. Despite this and the fact that the dependent variable is the first difference of stock, the R^2's in Table 12.2 are relatively high.

The coefficients of lagged stock are negative and significant in all equations. The coefficient might be interpreted to mean: (a) the adjustment rate (model I), (b) the depreciation rate (model J), (c) an expression of farmers' desire to reduce annual purchases when stocks are high, or (d) the cumulative influence of variables correlated with

[1] Subtraction of a quantity essentially proportional ($o < h < 1$) to the dependent variable is similar to dividing the dependent variable by a constant and, of course, moves the coefficients of the independent variables toward zero.

stock but not included in the equation (such as farm size, amount of liquid assets, technological advances and improved knowledge of the profitability and convenience of greater investment). These interpretations are not mutually exclusive, of course. Fortunately, model G, Chapter 11 (Table 11.1), indicates that the adjustment and depreciation rates approximately are equal. Since the estimates of elasticities and long-run equilibrium are not influenced by the interpretation, it is not necessary to specify whether the equations in Table 12.2 represent model I or J. A depreciation rate of .10, indicated by equations (12.11) and (12.12), is considerably lower than the rate ordinarily expected (and the one used in this study) for machinery. On the other hand, it is higher than the rate expected and used for building improvements. As an aggregate for the two categories, there is no basis for rejecting the estimate as unrealistic. However, if there is a positive net influence on investment of variables correlated with lagged stock but excluded from the equation, the coefficient of lagged stock is expected to be biased toward zero. Because the long-run coefficients are found by dividing the price and income coefficients by an adjustment coefficient biased toward zero, the estimated coefficients probably represent the upper boundary of long-run response to price and income.

Prices of investment items are not always available, and it sometimes may be useful and meaningful to substitute income for the price variable $(P_I/P_R)_t$. This step is taken for the equations in Table 12.3. Advantages of this step include: (a) adequate measures of P_I/P_R and E are not available for earlier years, substitution of Y_F permits estimation of the equations back to 1913; (b) the use of income rather than price permits a measure of the total marginal propensity to invest out of net income; and (c) use of current net income rather than P_I/P_R may reduce the ambiguity in interpreting results. Price and income variables are, of course, related. The variable P_R is common in each and P_I is correlated with some of the prices paid P_P by farmers for items used in production and which implicitly are included in net farm income. Because of the collinearity among input prices, interpretation of the influence of P_I on investment is difficult. The elasticity of investment with respect to P_I might, in fact, be the elasticity with respect to P_P. Of course, if the price of investment durables is the relevant short-run decision variable as implied in Tables 12.1 and 12.2, substitution of Y_F for P_I/P_R is not appropriate. The results in Table 12.3 are presented in order to allow comparisons of this type.

The level of significance of the income coefficient, the multiple coefficient of determination and magnitude of the coefficient of lagged stock S_{It} are generally at lower levels when Y_{Ft} is substituted for $(P_I/P_R)_t$. The results in Table 12.2, in comparison with those in Table 12.3, would support the hypothesis that the price of durable investment items is important in the investment decision function. (Equations computed but not shown indicate, however, that a lagged price variable, P_I/P_R, is overshadowed by adequately specified income variables.) Or perhaps a more realistic statement is that the results support the

Table 12.4. Elasticities of Investment Demand for the Aggregate Stock of Farm Machinery and Buildings S_I With Respect to Price and Net Farm Income Computed From the Equations in Tables 12.1, 12.2 and 12.3*

Equation	Model	Dependent Variable	Short run† (1-2 years) P_I	Short run† (1-2 years) P_R	Intermediate run‡ (3-4 years) P_I	Intermediate run‡ (3-4 years) P_P	Intermediate run‡ (3-4 years) P_R	Long run§ (many years) P_I	Long run§ (many years) P_P	Long run§ (many years) P_R	Adjustment or depreciation coefficient
(12.1)	B	Q_{It}	-.080	.080	-.080	-.16	.24	-.73	-1.45	2.18	.11#
(12.4)	C	Q_{It}	-.074	.074	-.074	-.15	.22	-.67	-1.36	2.00	.11#
(12.10)	BI	ΔS_{It}	-.078	.078	-.078	-.14	.22	-.71	-1.27	2.00	.11
(12.12)	CI	ΔS_{It}	-.071	.071	-.071	-.13	.20	-.71	-1.30	2.00	.10
			Y_F			Y_F			Y_F		
(12.14)	BI	ΔS_{It}	.073			.18			3.34		.054
(12.16) (1926-59)	CI	ΔS_{It}	.067			.13			2.73		.048
(1913-59)			.069			.13			2.98		.043

*See the text and Tables 12.1, 12.2 and 12.3 for discussion of data, methodology, coefficients, standard errors and related statistics. Elasticities are computed at the means.

†Price elasticities are computed from the coefficient of current price $(P_I/P_R)_t$; income elasticities from current income Y_{Ft}.

‡A 1 percent change in the parity ratio P_R/P_P is assumed to be associated on the average with a 2 percent change in net farm income. Translation of intermediate-run elasticities of E and Y_F to prices by multiplication of elasticities is done for convenience, but may impart some upward bias to the results. The price elasticities from the model B equations including equity E are computed on the assumption that a sustained increase of 1 percent in net income will in three or four years cause the equity ratio to increase 1.57 percent (cf. equation (11.15), chapter 11). The intermediate-run elasticity with respect to P_R is the price P_R component of income or equity plus the short-run price elasticity. Since P_I is not an important component of equity or income, the short-run and intermediate-run elasticities are identical.

§The intermediate-run elasticities divided by the adjustment coefficient g.

The elasticity estimates are "corrected" for the noncomparability of the dependent variables by adding $h S_{It}$ to the mean of $\bar{S}_{It+1}$ in equations (12.1) and (12.4), because the dependent variable is $S_{It+1} - S_{It} + h S_{It}$ rather than $S_{It+1} - S_{It}$.

#Assumed adjustment coefficients, based on Table 12.2. The number of years N required to make T proportion of the adjustment to equilibrium at the annual adjustment rate g is $N = \frac{\log(1-T)}{\log(1-g)}$. If the adjustment rate is .11, approximately 20 years are required to make 90 percent of the total adjustment.

hypothesis that the price of durable investment items, taken alone, is important in the decision framework, but only in the short run. The important concern of the farmer is ability to pay for the newly acquired asset out of future earnings. Hence, expected earnings, reflected by past net farm income, is an important element in the investment function.

The coefficients of income in equation (12.15) decline with "remoteness" of time, and the results suggest that additional lags would add little to the explanation of investment. Coefficients for the income variable lagged two years were significant only at a low probability level. The similarity of the results in (12.15) and (12.16) also suggests that further income lags are unnecessary. In equation (12.17), with a four year income lag, the coefficient of Y_{WFt-1} is not significant and the variable is deleted to form equation (12.18). The hypothesis is that income of each of the past four years (e.g. the arithmetic average of four years) exerts an equal influence on current investment. Equation (12.16), which depicts a declining income effect, gives a larger R^2 and coefficient of past income and is a more reasonable expression of the investment function than equation (12.18). Model DI was also estimated with a three year income lag. The results were very similar to those in equations (12.17) and (12.18) and are not presented.

Equations for both time periods are consistent in indicating a marginal propensity to invest of .2 (Table 12.3). A sustained rise of one million dollars in net income is predicted to increase annual net investment in agricultural plant and equipment by 200 thousand dollars.

Price and Income Elasticities

Equations in Table 12.1 ideally are best suited for estimating the elasticity of gross annual investment or purchases; those in Tables 12.2 and 12.3 for estimating the elasticity of demand for investment stock. As anticipated, the price elasticities of demand for Q_I are similar to those computed for machinery in Chapter 11 and need little further discussion. The elasticity of Q_I with respect to P_I computed from equation (12.4) is -.76. The elasticity of annual purchases with respect to P_R computed from the same equation is .76 in the short run (current and past year) and 2.3 in the long run (three or four years). Equation (12.6) indicates that the adjustment of annual purchases to the desired level substantially is complete in four years.

From estimates in Table 12.4, the demand for stock of machinery and building improvements is highly inelastic in the short run. Stock is responsive to price changes in the long run, but if the adjustment coefficient is .11, only 90 percent of the total adjustment is completed in 20 years. Equations (12.1), (12.4), (12.10) and (12.12) indicate that the elasticity of investment stock S_I with respect to P_I approximates -.1 in the short run and -.7 in the long run. From the same equations, the elasticity of S_I with respect to P_R approximates .1 in the short run,

.2 in the intermediate run and 2.0 in the long run. With an elasticity of -1.3, the results also show stock to be quite responsive in the long run to changes in prices paid by farmers P_P. Equity and net income in equations (12.1), (12.4), (12.10) and (12.12) are translated to prices by the definitional equation (11.15). Since price ratios are used throughout, the investment functions are homogeneous of degree zero in prices.

Due to the similarity of response of annual investment to price changes, inferences about the aggregate may be extended to the components of Q_I. But because of the lack of uniformity in depreciation rates, adjustment rates and ratios of annual purchases to stock, it is inadvisable to generalize results of the aggregate functions in Table 12.4 for machinery stock S_M and building stock S_B. The equations in Table 12.2 indicate that the depreciation or adjustment rate for the aggregate investment function is .11. The rate for machinery is considerably greater than this figure and for building improvements is considerably less than this estimate based on the results in Chapters 11 and 15.

Equations (12.14) and (12.16) provide the basis for estimating the income elasticity of demand for investment stock. Because current net income does not appear to be an adequate substitute for prices, and because the equations in Table 12.3 are inferior in other respects to those in Table 12.2, the derived income elasticities should be regarded as tentative estimates. The income elasticity of stock demand is .07 in the short run, .1 or .2 in the intermediate run and approximately 3.0 in the long run according to equations (12.14) and (12.16). These estimates, particularly the long-run estimates, appear to be unusually large. The adjustment coefficients are low and, since the intermediate-run elasticities are divided by the adjustment coefficient to form the long-run elasticities, the latter are inversely related to the size of the adjustment coefficient. The adjustment coefficients are expected to be biased toward zero because of correlations with variables exerting a positive influence on net investment. Thus, the elasticity estimates may be taken to represent the upper boundary in response.

Shifts in Investment

Equation (12.1) is used for estimating sources of shifts in annual investment Q_I from 1926 to 1959. The actual increase in annual investment between 1926 and 1959 was 105 percent. Equation (12.1) estimates 108 percent, a very slight difference. Equation (12.1) predicts that, with price ratio P_I/P_R at the 1959 level in 1926, annual investment would have been 60 percent less than the predicted demand at the earlier date. If the equity variable, E, is set at the 1959 level for 1926, ceteris paribus, the predicted demand quantity for the earlier date would have been 69 percent greater than the predicted amount for 1926 with E and other variables at the values of the earlier year. Hence, the price and financial influences nearly offset each other. If the price and equity variables both are set at the 1926 level, (12.1) predicts a 99 percent increase in demand by 1959 due to slowly changing forces aggregated into the time variable, T. These forces represent new technology such as improved machinery, increased general knowledge by farmers and related influences tending to increase farm investment. The replacement demand is ignored in equation (12.1). If the adjustment and depreciation rates are equal, as indicated by equation (12.8), the "adjustment quantity" and replacement demand are offsetting, and both may be ignored according to model G.

Trends and Projections

Figure 12.1 compares historic trends in annual gross investment, Q_I, and stock, S_I. Equation (12.12) is used for prediction in the figure.

The two series displayed similar trends prior to the war. Annual investment and stock both were much greater in 1948 than in 1941. Farmers evidently obtained sufficient quantities of investment items to more than replace depreciated stock during the 1942-47 period. While annual investment declined in the postwar period, stock continued to increase because annual investment exceeded replacement requirements. By 1955, annual purchases approached replacement requirements, and total stock began to level off. In 1956 and 1957, depreciation was greater than purchases, and the stock of durables S_I declined. However, price and income improvement in 1958 and 1959 again allowed additions to stock.

The predictions in Figure 12.1 (solid line) are made with equation (12.12) through the identity in (12.20), where $\Delta S'_{It}$ is the change in stock predicted by equation (12.12) and S_{It} is the known beginning year stock. (The notation "t+1" is used because the "ending year" stock actually is the January 1 stock of the following year t+1.)

(12.19) $$S_{It+1} - S_{It} = \Delta S_{It}$$

(12.20) $$S'_{It+i} = \Delta S'_I + S_{It}$$

The predicted annual gross investment, Q'_{It}, is computed from identity equation (12.9) as

(12.21) $$Q'_{It} = \Delta S'_{It} + hS_{It}\,.$$

The depreciation rate h is the coefficient of lagged stock according to model J. While equation (12.12) predicts well in the postwar years, the depreciation rate appears to be inaccurate in the prewar years. The assumption of a fixed rate h over the entire period may be too rigid. The depreciation rate may well have declined over the period covered. Equation (12.12) predicts annual investment more accurately in recent years than did several equations used to predict machinery quantities in Chapter 11. The equation predicts stock very well over the entire period (the upper graph of S_I).

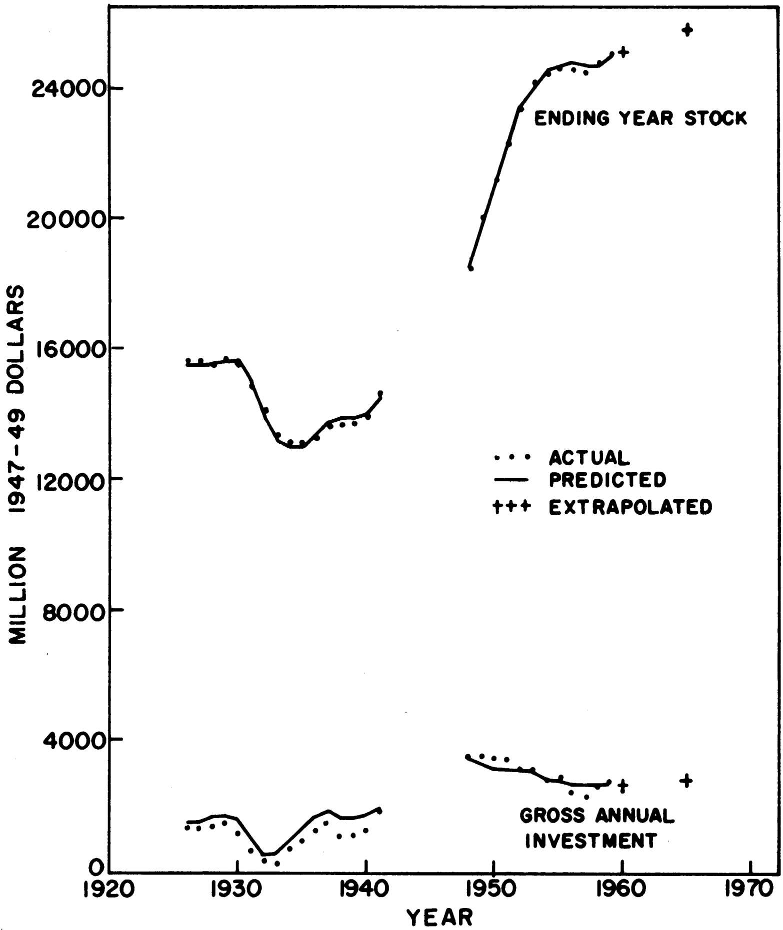

Figure 12.1. Trends in ending year stock S_I and gross annual investment Q_I in all farm machinery and building improvements from 1926 to 1960 (predicted and projected estimates from equation 12.12).

Equation (12.12) also was used for projecting investment stock and purchases to 1965. (The term "projection" is used because assumptions are made for the 1965 levels of the price and net income variables.) Based on assumptions of income at the 1955-59 average level, and prices 10 percent above 1960 prices (the price increase spread proportionately over the 1960-65 period), 1965 gross annual investment and stocks both are projected to be 3 percent above their predicted 1960 levels. Using (12.4) with Q_I the dependent variable, projected 1965 annual investment is 2.8 billion 1947-49 dollars, or 3.5 percent greater than the 1960 predicted level under the same assumptions. These results are quite similar, but other projections would be obtained for alternative price and income assumptions. (The standard errors of the projected estimates were not computed but would be large for distant extrapolations.)

TOTAL FARM INVESTMENT IN ALL PRODUCTIVE ASSETS

We now make an even more highly aggregated analysis of farm investment, with the measure being all productive assets on farms. This dependent variable includes machinery, real estate, livestock, feed and cash held for use in production. The specification of the investment function for this measure of productive assets is similar to that for machinery and building improvements discussed above. Some differences should be mentioned, however. The price of all productive assets is not readily available and was not constructed for the analysis which follows. A quantity indirectly representing an imputed price or net value productivity is net farm income. Net farm income is the residual after paying production costs, and is the approximate return on durable assets and family labor (assuming constant returns to scale). If farmers ignore the family labor component, and subjectively impute the entire residual return to durable assets, net income can be considered an imputed price for productive assets.

Specification of Investment Function for All Productive Assets

The following variables are included in the investment function for all productive assets:

S_{pt} = the stock of productive assets on farms January 1 of the current year. The variable includes machinery, real estate, feed, livestock and cash inventories held for productive purposes and is measured in 10 millions of 1947-49 dollars.

ΔS_{pt} = the first difference of the foregoing variable, S_p, is the dependent variable. It is the net annual investment in productive assets, i.e., the change in total stock during the current year.

Y_{Ft} = the net income of farm operators from farming during the current year, deflated by the index of prices paid by farmers for items used in production, including interest, taxes and wage rates. Net income includes cash receipts, government payments and nonmoney income less production expenses in millions of 1947-49 dollars.

Y_{DFt} = the declining three year arithmetic average of Y_F. Current year income, Y_{Ft}, is weighted by .50, the past year, Y_{Ft-1}, by .33 and the previous year, Y_{Ft-2}, by .17.

Table 12.5. Annual Net Investment in Productive Farm Assets ΔS_p Estimated by Least Squares With Annual Data From 1926 to 1959 and 1913 to 1959, Omitting 1942 to 1947 in Each Series; Coefficients, Standard Errors (in Parentheses) and Related Statistics Are Included*

Equation and Years†	R^2	d‡	Constant	Y_F t	Y_{DF} t	Y_{DF} t-1	Y_{AF} t-1	O t-1	$\overline{O}$ t-1	W t	T	S_p t
(12.22) (1926-59)	.751	1.67	-142.53	.0242		.0083				2.10	3.67	-.052
				(.0090)		(.0077)				(1.19)	(3.64)	(.040)
(1913-59)	.690	1.19	-106.85	.0261		.0084				1.14	2.88	-.044
				(.0061)		(.0063)				(.88)	(1.32)	(.025)
(12.23) (1926-59)	.734	1.67	-72.89		.0305					2.42	4.93	-.067
					(.0066)					(1.17)	(3.50)	(.025)
(1913-59)	.663	1.20	-67.56		.0339					1.38	3.20	-.052
					(.0050)					(.90)	(1.34)	(.025)
(12.24) (1926-59)	.759	1.72	-105.64	.0234			.0099			2.15	3.73	-.058
				(.0084)			(.0072)			(1.17)	(3.58)	(.040)
(1913-59)	.700	1.19	-67.96	.0261			.0101			1.13	2.98	-.051
				(.0054)			(.0058)			(.86)	(1.30)	(.025)
(12.25) (1926-59)	.738	1.64	-195.46	.0309						1.99	3.36	-.042
				(.0065)						(1.19)	(3.64)	(.039)
(1913-59)	.675	1.19	-166.20	.0316						1.09	2.65	-.033
				(.0046)						(.89)	(1.32)	(.024)
(12.26) (1926-59)	.821	2.10	455.13	.0320		-.0032			.043	1.35	-3.19	-.188
				(.0083)		(.0078)			(.015)	(1.06)	(3.96)	(.059)
(12.27) (1913-59)	.740	1.62	202.71	.0319		.0018		.0216		.87	-1.21	-.114
				(.0061)		(.0064)		(.0085)		(.82)	(2.02)	(.036)
(12.28) (1926-59)	.778	1.88	412.00		.0273				.030	2.10	.95	-.175
					(.0063)				(.014)	(1.10)	(3.78)	(.062)
(12.29) (1913-59)	.683	1.49	138.37		.0336			.0126		1.29	.96	-.0971
					(.0050)			(.0084)		(.88)	(1.99)	(.0386)
(12.30) (1926-59)	.820	2.05	426.84	.0295					.040	1.44	-2.60	-.181
				(.0056)					(.013)	(1.02)	(3.62)	(.055)
(12.31) (1913-59)	.739	1.63	205.99	.0332				.0226		.85	-1.44	-.115
				(.0042)				(.0077)		(.81)	(1.84)	(.035)

*Sources and composition of the dependent variable ΔS_p and of the indicated dependent variables are discussed in the text.
† Estimated only from original observations. Adjustment models I or J are combined with expectation models discussed in Chapter 10.
‡ The Durbin-Watson autocorrelation statistic d.

Y_{AFt-1} = the simple past four year average of Y_F.

O_{t-1} = farm output during the past year in millions of 1947-49 dollars.

$\bar{O}_{t-1}$ = the simple average of farm output over the past two years.

W_t = Stallings' index of the influence of weather on farm output in the current year. Stalling's data extend only to 1957. Observations for 1958 and 1959 are computed from the deviations from a linear yield trend.

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

All variables are aggregate annual observations for the United States from 1913 to 1941 and from 1948 to 1959 except $\bar{O}_{t-1}$ which was not computed for 1913 to 1925.

Past output is included in the investment function for all productive assets because of the "fixed relationship" between asset stocks and output. Output may be increased in the short run by substituting more operating inputs into the resource mix, but output also is quite closely a function of fixed asset stocks or durable capital. Livestock and feed inventories are sensitive to weather conditions. Accordingly, a measure of weather was included in the investment function. Theoretically, the decision to invest is a function of the discount rate as well as expected future returns. Two measures of the discount rate were included in the investment function: (a) the short-term interest rate on loans to farmers and (b) the rate of return on industrial common stock. These rates were included directly in the investment function and also as ratios to the rate of return on investment in agriculture (residual farm income divided by the total farm assets). However, the coefficients of all these variables were not significant.

Because estimates of gross annual investment are not available, but estimates of stock are contained in secondary sources, model I or J appears appropriate and is used.

First differences of income and output variables were included in the functions, but they did not significantly improve the explanation of net investment. Depending on the variables specified in the function, it might appear that a regression coefficient for farm size might be significant in explaining total investment. However, because of the high correlation between beginning year stock and farm size, the latter variable is excluded from the investment function.

Least-Squares Estimates of Investment

Income, weather, time and beginning year stock explain 75 percent of the variation in annual net investment in equation (12.22), Table 12.5. Current year income exerts the major proportion of the total influence of income on annual investment. Some least-squares bias is suspected, since Y_{Ft} and the errors in the dependent variable are correlated. The variable in equation (12.23) which forces the income influence to be spread over three years has logical appeal because of the nature of farm decision process, and is consistent with results of the investment analyses presented previously. The time variable is not significant in the equations estimated for the 1926-59 period. The technological forces and other influences represented by it may be absorbed by the beginning year stock variable. Over the longer period, however, the stock variable evidently does not adequately incorporate these forces, and the time variable is significant in equations (12.22)-(12.25) for the 1913-59 period. The degree of autocorrelation in the residuals, as indicated by the d statistic, is low for the equations from 1926-59 data. However, structural changes over time not accommodated in the model appear to produce autocorrelation in the residuals for equations from 1913-59 data.

The introduction of an accelerator effect through inclusion of the lagged output variable reduces autocorrelation in investment equations (12.26)-(12.31). The absolute magnitude and significance of the coefficient of the lagged stock variable also are increased. Some instability is exhibited in the magnitude of the accelerator coefficient, depending on the form of the output variable. Coefficients of both output variables are significant, but the variable measured as a two year average has a greater quantitative effect on net annual investment.

Although introduction of an accelerator effect increases the R^2 and reduces autocorrelation, it introduces more collinearity among variables. In (12.23) for example, the highest simple correlation, .82, was between S_{pt} and T. Correlations are higher in equations which include lagged output, the simple correlation being .93 between $\bar{O}_{t-i}$ and S_{pt} in (12.30). Introduction of lagged output in the equation thus creates problems of coefficient instability, interpretation difficulties and other features associated with multicollinearity. Given these limitations, lagged output does improve the explanation of annual net investment, and the specification does not seem to be complete without some type of accelerator variable.

The measurement unit for the dependent variable is ten times larger than that for income and output. The effect of a one-unit increase in income or output on an investment unit can be expressed, however, by shifting the decimal point of the respective coefficients one place to the right. The "marginal propensity to invest," in relation to net income is approximately .3. The finding should not be interpreted to mean that farmers invest 30 cents from each dollar of net income. The interpretation must be less precise and more nearly mean that a sustained 1 million dollar increase in net income eventually will increase annual investment 300 thousand dollars or more in U.S. agriculture. The term "or more" is used because a recursive or "lagged adjustment" influence on investment is expected through the accelerator. There is a direct influence on investment from farm income (from the explicitly specified income variables in the equations), and an indirect influence from favorable farm prices which increase farm output, causing additional investment through the technical relations discussed earlier. The relationship between income and investment also is indirect because: (a) The measure of income, Y_F, used in this study includes nonmoney income, for example. Other concepts of income would result in other estimates of the marginal propensity to invest. (b) Many components of S_p are farm produced rather than cash purchases, and additional net income may first be invested in operating inputs, before inventories of livestock and feed are increased. (c) External credit sources may become more favorable and provide funds for investment when net farm income increases.

Elasticities With Respect to Price and Income

Table 12.6 includes price and income elasticities, for investment stock, S_p, with respect to prices and net income, computed from equations in Table 12.5. The income elasticities are translated into price elasticities by the definitional equation discussed elsewhere. The definitional equation indicates that a 1 percent increase in the parity ratio has been associated, as an average for the period analyzed, with a 2 percent increase in net income. The elasticities with respect to prices paid, P_P, are those (or "the same as those") given for P_R/P_P but with a negative sign. The results indicate the price or income elasticity of stock is low in the short run. A sustained 1 percent increase in net income increases the stock of productive assets only .02 percent in the short run and .04 percent in the intermediate run. Demand for investment stock is highly inelastic in the short run because time and capital restrain the rate at which livestock, feed and other inventories and resources can be increased. Demand becomes much more responsive in the long run. The long-run elasticities, computed by dividing the

Table 12.6. Elasticities of Investment Demand for the Stock of All Productive Assets S_p With Respect to Price and Net Farm Income Computed From the Equations in Table 12.5*

	Short Run (1-2 years)		Intermediate Run (3-4 years)		Long Run (many years)		Adjustment or Depreciation Coefficient
Equation and Year	Y_F†	P_R/P_P‡	Y_F†	P_R/P_P‡	Y_F§	P_R/P_P‡	
(12.23) (1926-59)	.017	.035	.035	.069	.52	1.03	.067
(12.23) (1913-59)	.019	.039	.039	.077	.74	1.49	.052
(12.28) (1926-59)	.016	.031	.031	.062	.20	.39	.175
(12.29) (1913-59)	.019	.038	.038	.077	.41	.82	.097

*See the text and Table 12.5 for discussion of data, methodology, coefficients, standard errors and related statistics. Elasticities are computed at the means.

†Computed from the declining three year average net farm income variable Y_{DFt}, which implies that one-half the elasticity is attributed to the current year.

‡Assuming that on the average a 1 percent increase in price is associated with a 2 percent increase in net income.

§Found by dividing the intermediate-run elasticity by the adjustment coefficient g. If the adjustment coefficient is .10, over 20 years are required to make 90 percent of the total long-run adjustment.

intermediate-run elasticities by the coefficient of lagged stock, lack uniformity among equations incorporating the lagged variable because the adjustment coefficients vary considerably in magnitude among models. Within this framework, and as an "average," a sustained 1 percent increase in income Y_F may increase annual investment stock by 1/2 of 1 percent in the long run. Similarly, a 1 percent sustained increase in P_R (decrease in P_P) in the long run is expected to increase the level of investment stock 1 percent. The "long run" is distant, however. Twenty-two years are required to make 90 percent of the long-run adjustment if the adjustment rate is .10.[2]

Shifts in Investment

The aggregate stock of productive assets, S_p, as defined above, increased by 30 percent between 1926 and 1959. Stock at the end of a given year is the sum of the carryover from the past years plus annual investment in the particular year. The 1959 stock was much greater than the 1926 stock because a larger volume of inventories was accumulated over the period as a result of net positive investment. Interpretation of the effect of individual variables on S_p through investment for each year 1926 to 1959 is cumbersome. Hence, to provide some insight into the annual investment process, equation (12.22) is assumed to be model J, and the influence of income and the time variable on annual investment is compared for the two extreme years only. It is likely that the types of influences registered for these years will also provide some insight into a comparison of annual investment behavior between other years.

Predicted from (12.22), gross annual investment in 1959 was 42 percent greater than in 1926. Had net farm income been at the 1959 level in 1926, ceteris paribus, the equation indicates that the demand quantity would have been only 7 percent greater. Setting only the time variable at the 1959 value, leaving other variables at 1926 values, a 27 percent increase in demand is predicted. (The weather variable explains the difference between the total increase, 42 percent, and the sum of the income and time influences, 34 percent.)

To further examine sources of the increase in gross annual investment, estimates from equation (12.29) are used. The equation predicts a 34 percent total increase in annual investment between 1926 and 1959. Setting the income variable at the 1959 level, other variables at the 1926 level, the equation indicates only a 5 percent increase in investment. If the income component of output could be included, the increase due to income would be more consistent with the 7 percent increase due to income estimated from equation (12.22). If time is set at the 1959

[2] In these estimates, the coefficients from equation (16.3) are taken as the influence of prices on output, and this accelerator influence is added to the elasticities computed from equations (12.28) and (12.29).

level and other variables at 1926 values, equation (12.29) predicts only a 4 percent increase in annual investment. Following the same procedure for the output variable, the equation predicts a 22 percent increase in demand. The sum of the increase attributed to time and to output is 26 percent, an amount agreeing closely with the 27 percent increase associated with time in equation (12.22) which excluded the output variable. Time and output are highly correlated, and information is unavailable to distinguish the relative influence on annual investment of factors reflected in each. Mainly, our results indicate that a major portion of the secular increase in annual investment in productive assets is associated with gradually shifting variables related to time and output rather than to net income. These "shift" variables include technical changes which increase the marginal productivity of capital. Evidently these forces were more important than income in explaining the secular trend of investment. Although these forces largely explain the secular shift, year-to-year fluctuations in investment are more closely identified with changes in the volatile net income variable. Caution is suggested in interpreting the above results because of inadequate specification of labor price and of the recursive price influence on output and investment.

Trends and Projections

The stock of productive assets increased slowly from 1928 to 1930, then dropped during the depression years up to 1935 (Figure 12.2). The stock of productive assets then began a continuous increase. While the upward trend showed signs of reversal in 1956 and 1957, the 1958 and 1959 observations suggest a linear rather than declining postwar trend. Equation (12.28) predicts close to actual observations over the entire period; it does not predict so well in periods of sluggish investment such as 1938-39 and 1956-57.

With 1955-59 average net income, an 8 percent increase in farm output[3] and $T = 65$, equation (12.28) projects 1965 investment stock to be 5.5 percent above the 1960 stock. Thus, the upward trend in stock, depicted in Figure 12.2, is projected to continue.

Gross annual investment is estimated from equation (12.28) (bottom of Figure 12.2) assuming it is model J and employing the prediction relationship indicated by equation (12.21). So estimated, gross annual investment has been fairly stable over the entire period. Except for the early 1930's, gross annual investment was greater than replacement requirements, and net additions were made to total stock.

Investment in all productive assets has been less volatile than investment in machinery and buildings. Buildings and machinery investment is more sensitive to economic conditions than investment in all

[3] Johnson, Sherman. Agricultural outlook in the 1960's. 38th Annual National Agricultural Outlook Conference. USDA. 1960.

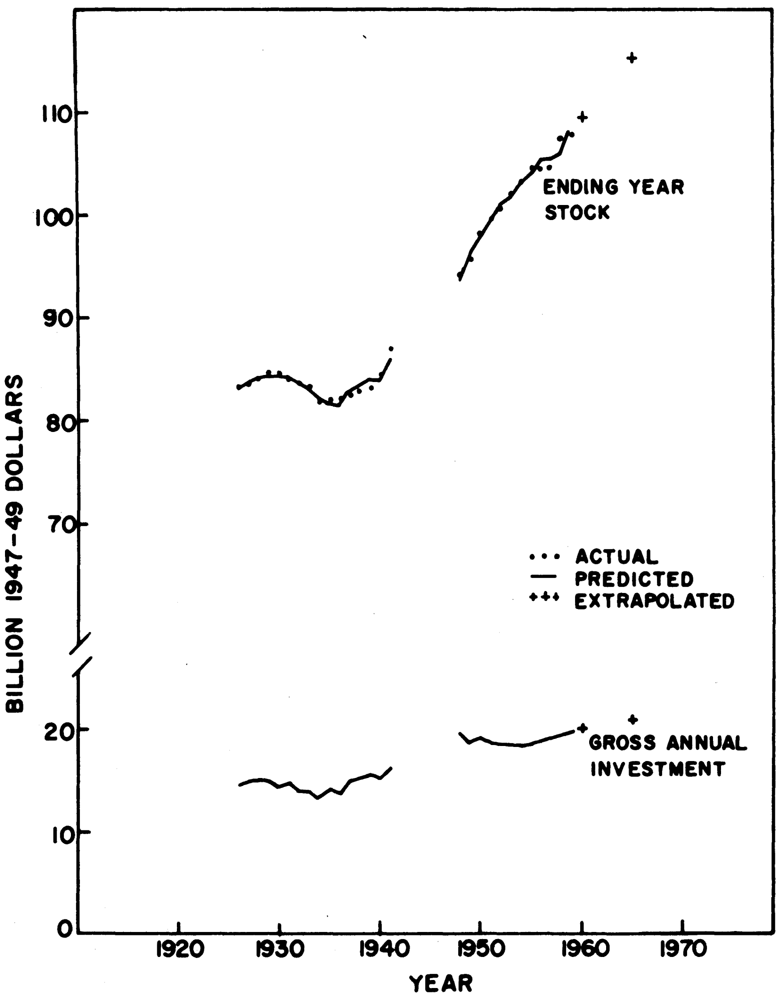

Figure 12.2. Trends in ending year stock S_p and gross annual investment Q_p in productive assets (predicted and projected estimates from equation 12.28).

productive assets because farm produced durables are included in the latter. The supply elasticity and reservation price for farm resources such as land and secondhand buildings and equipment are low. Even when market prices are relatively unfavorable, there are few alternative uses for these "fixed" resources. "Productive" livestock and feed inventories which are not held for current or even future production but are for direct future sales should not be classified as productive assets. However, techniques used to ascertain the quantities of assets are not always adequate for distinguishing between these two categories of farm produced assets.

Based on the same assumptions used above to project S_p to 1965, annual investment Q_p is projected to be 5 percent above the 1960 predicted quantity by 1965 (Figure 12.2). It is expected that this equation predicts the changes in annual investment more accurately than the level of annual investment. The depreciation rate may be too high, and the estimated level of gross investment may contain an upward bias.

POLICY IMPLICATIONS

Farm investment behavior for two aggregate categories of investment, the productive portion of building improvements and farm machinery, and all farm productive assets have been investigated in this chapter. The models used are somewhat simple and do not exploit all alternatives which might be investigated. They have obvious limitations. Within this framwork of limitations, however, the equations suggest a propensity to invest in relation to net income of .2 for machinery and buildings as an aggregate and .3 for all productive farm assets. Since more items are included in the second category, a higher marginal propensity to invest is expected.

Some modern theories of economic growth express national development as a function of two parameters (a) the marginal propensity to invest and (b) the output/capital ratio. The high marginal propensity of U.S. farmers to invest, coupled with the tendency to substitute more productive for less productive capital, accounts for a pattern of growth in output per man-hour unequaled on farms in other parts of the world. The marginal propensity to invest is a function of the education of farmers and of the availability and profitability of investment items, making them attractive to farmers. Both the public and private nonfarm sectors have been important causal agents creating this environment which encourages capital accumulation. Also important is the value system of farmers and the stage of economic development on farms. If farmers had consumed all surplus output (income) because of the necessity to meet subsistence living requirements or because their value structure contained no savings and accumulation ethic, the growth pattern, not only of agriculture but also of the nation, would have been different indeed.

The elasticity of aggregate investment stock, S_I, with respect to own price, P_I, is estimated as approximately -.1 in the short run (one or two years) and -.7 in the long run (over 20 years). The elasticity of S_I with respect to P_R is .1 in the short run (one or two years), .2 in the intermediate run (three to four years) and 2.0 in the long run (over 20 years). The elasticity of investment stock in productive assets, S_p, with respect to P_R is estimated to be .04 in the short run (one or two years), .07 in the intermediate run (three or four years) and 1.0 in the long run (over 20 years).

Some interesting patterns in the elasticities are apparent. As expected, the price elasticities of productive assets, S_p, are consistently lower than those of machinery and improvements, S_I. Because of the nature of the production process in agriculture, livestock inventories cannot be readily increased, and some components of real estate inputs are highly restricted. Stock has a low price elasticity in the short run for reasons explained earlier. In the long run, however, stock appears to be very responsive to price changes according to the analysis. Government policies and other influences on farm product prices thus may have little influence on stock, and consequently on output through S_P, in the short run. The influence on stock might be sizeable in the long run, however. Although stock is not sensitive to price changes in the short run, annual investment is highly responsive. For example, the elasticity of Q_I with respect to P_R is approximately 1.0 in the short run (one or two years) and more than 2.0 in the long run (three or four years). This sensitivity of annual investment to prices is a potential source of business fluctuations, but the effect can be dampened by the remaining large private economic sector and by government spending.