15.

Real Estate Prices and Investment, and Farm Numbers

TWO SEGMENTS of the real estate structure, land price and investment in land improvements [considered in this chapter], complete our analysis of the major resource categories. Though not a resource per se, farm numbers have been an integral part of the resource structure of agriculture. For this reason the final section of this chapter contains an attempt to estimate structural parameters determining farm numbers. The analysis again is based on aggregate data for the United States because time, space and dollar resources do not permit a further breakdown by region and commodity.

LAND PRICE

In the absence of structural change, we could expect variations in land price to correlate positively with changes in net farm income. That this relationship has not held is apparent from Table 15.1. Both net farm income and land prices increased during the war period. Net income began a general decline after 1950 and was only 84 percent of the 1947-49 average in 1961. Land prices continued to rise in the period, however, and in 1961 were 75 percent above the 1947-49 average. We examine hypotheses explaining this phenomenon in this chapter.

Another reason for exploring the structural basis of land prices is their role in farm policy and in resource adjustments. The effectiveness and incidence of a government program to raise farm incomes depend to some extent on the rate that these benefits are capitalized into land values. Additional incomes quickly capitalized into real estate prices benefit present land owners but the results for future generations may be quite different. Higher land values creating barriers to entry for beginning farmers may have both favorable and unfavorable effects on optimum resource adjustments.

Higher land values possibly encourage labor movement to nonfarm areas, but also potentially retard diversion of land into uses considered more worth while by society.

Farm appraisers, participants in land market operations and credit groups in agriculture also are concerned with the effects of structural variables on land values. Whether a real estate loan is granted may

Table 15.1. Indices of Farm Real Estate Values per Acre and Net Farm Income, 1940 to 1961*

Year	1947-49 = 100	
	Real Estate Value (per acre)	Total Net Income (Gross income less production expense)
1940	49	30
1945	76	80
1950	103	91
1955	133	76
1960	173	78
1961	175	84

*Statistical Abstract of the United States, 1961; and USDA. The Farm Income Situation. 1961 and March 1962.

depend on future trends in land prices, and knowledge of forces affecting these trends allows more accurate predictions. Finally, long-range public planning of recreation areas, industrial sites and residential zoning is tied to land values. Technologically improved inputs prompting a secular decline in land values in agriculture influence the purchase price of land for alternative uses and affect the tax base for land used to produce crops.

We hope that results in this section will begin to provide basic information for these and related problems by measuring not only the extent but also the rate at which additional net income and other effects are capitalized into land values.

Specification of the Land Price Function

While in most time series analysis there are more admissible hypotheses (variables) explaining the dependent variable than can be included in the regression equation, the dilemma appears especially acute for land prices. This prompts us to specify a land price model as a hierarchy of admissible hypotheses in an attempt to preserve structural validity and to avoid some of the difficulties of spurious correlations associated with collinearities.[1] Each of the following subsections may be considered a hierarchy of one or more variables. A variable from the higher echelon is selected before moving to the next lower echelon. When the intercorrelations become high, causing instability in the coefficients and large standard errors, no further variables are added.

[1] Some of the theoretical advantages of this system are discussed in Tweeten, Luther G. An Economic Analysis of the Resource Structure of United States Agriculture. Unpublished Ph.D. Thesis. Library, Iowa State University. Ames. 1962. Chap. 3.

Farm Size and Machinery

The structural variable most frequently associated with recent trends in land prices is the growing demand for land to be used for farm enlargement. For example: A farmer owning 160 acres with receipts above variable costs of \$50 per acre and with nonland fixed costs of \$30 per acre earns \$20 as the imputed return to land. Based on a discount rate of 10 percent, he could pay \$20/.10 = \$200 per acre for the "home" acreage. But suppose an additional 40 acres is available nearby and he can farm it with existing machinery and other "fixed," discrete inputs. Again the receipts above operating costs are \$50 per acre, and since marginal machinery and other overhead costs are near zero, the return to land is nearly \$50. Discounting at the same rate as before, the farmer may pay up to \$50/.10 = \$500 per acre for the additional 40 acres. It is clear that in circumstances where available equipment can be used profitably on more acres, farmers intending to expand acreage can outbid those intending to farm only the purchased land. This effect is included in the land price function with a farm size variable, A. Since the effect is also closely tied with machinery investment, it is also partially represented by a machinery stock variable, S_M. The first hierarchy is therefore (15.1) where P is land price.

$$P = f_1 (A, S_M) \tag{15.1}$$

Income and Discount Rate

The land value model essentially is a modification of the capitalization formula P = Y/r where P is land price per acre, Y is the residual income per acre of land and r is the discount rate or highest rate of return on alternative investments. Assuming the annual return, Y, is sustained in perpetuity, the discounted present value of one acre is P. If the price asked for land is greater than P, investors would find other alternatives more profitable; if the asking price is less than P, investors would find land a profitable investment and would bid up the selling price. Thus, under competitive conditions land values would move toward the discounted value of the annual residual income or imputed return to land.

This analysis is predictive rather than normative, hence, we are concerned with the residual income farmers subjectively impute to land rather than what is, in fact, the residual return to land.[2] For example, many farmers may impute little return to their own labor,

[2] The accounting residual return to land is equal to the contribution (value of marginal product) of land to returns only under restricted assumptions. Let the production function be

$$O = f(X, L) \tag{a}$$

where O is output, X is inputs other than land and L is land input. With constant returns, according to the Euler theorem.

rather imputing their labor return to land. Several suggested variables which may correlate with or represent the subjective return are gross farm income, Y_1, gross income less operating and hired labor expense, Y_2, gross income less all cash expenses, Y_3, and gross income less all cash operating and labor expenses and service costs of nonreal estate farm durables, Y_4. These and other measures of Y variables constitute the second hierarchy (15.2).

$$P = f_2(Y_1, Y_2, \ldots, Y_n) \tag{15.2}$$

These measures of land returns are influenced by farm size, machinery investment and other variables, hence the hierarchies are not independent or orthogonal.

The discount rate, r, may be interpreted as the opportunity cost of land investment, or the highest alternative rate on investment, allowing for uncertainty. A rational investor who can obtain a higher return by investing capital in farm operating inputs, mortgages or municipal bonds would not invest in real estate. If capital is plentiful the effective discount rate may be the short-term or bank interest rate, r_S, farm mortgage rate, r_L, or the rate of return on common industrial stock, r. The discount rate may be the return, r_I, on internal investment in machinery, fertilizer or other inputs if capital is more limited. This set of discount rates constitutes the third hierarchy (15.3).

$$P = f_3(r_S, r_L, r, r_I) \tag{15.3}$$

Assets and Technology

The form and magnitude of assets influence land prices both directly and indirectly through variables such as Y and r listed previously. A monetary surplus accumulated through a period of favorable farm prices reflected by liquid assets, S_L, or the equity ratio, E, could be expected to create pressures for higher land values. Rising

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$$O = \frac{\partial O}{\partial X} X + \frac{\partial O}{\partial L} L \tag{b}$$

In equilibrium

$$\frac{\partial O}{\partial X} P_y = P_x \tag{c}$$

where P_x is the price of input X, and P_y is output price. Multiplying (b) by product price, P_y, and substituting P_x from (c) for the value of marginal product, $\frac{\partial O}{\partial X} P_y$, the result is

$$O\, P_y = X\, P_x + \left(\frac{\partial O}{\partial L} P_y\right) L \tag{d}$$

and the accounting residual to land is equal to contribution of land to returns (e) under these restricted assumption.

$$O\, P_y - X\, P_x = \left(\frac{\partial O}{\partial L} P_y\right) L \tag{e}$$

Measure Y_4 in the text most nearly is equivalent to the left side of (e).

investment stocks, S_B, of buildings and other real estate improvements also increase land values. The effect on land price from expansion of cropland area by irrigation, drainage and clearing, or contraction from urban growth or other nonfarm uses is represented by total cropland acres, L_d. Both acreage, L_d, and real estate improvements, S_B, are included in the physical volume of real estate, S_{RE}.

The assumption of the single equation is that these variables influence land price but are not influenced by it. If the predicted value of L_d from a land supply function (see equation 16.14 in the following chapter) is used as the independent variable, then the land price function of this chapter may be considered the demand equation in a recursive model of land supply and demand. The recursive model allows price and quantity to be determined interdependently but not simultaneously in time (see Chapter 3). Investments in technologically improved inputs such as fertilizer, Q_{Fr}, and irrigation tend to increase the residual return to land and thus increase land values in the short run, particularly for early adopters. In the long run, as farmers use these inputs more intensively and additional farmers adopt the productive inputs, output rises, product price falls and farm income and land returns are depressed. The influence on land values of many of these gradual changes in capital structure can perhaps only be summarized in a time variable, T.

The fourth hierarchy therefore is summarized as (15.4) in terms of the variables defined above.

$$(15.4) \qquad P = f_4(S_L, E, S_B, L_d, S_{RE}, Q_{Fr}, T)$$

Miscellaneous Variables

Inflationary trends, P_T, government programs, G, and weather, W, are largely exogenous to the farm sector, and potentially influence farm real estate prices. Government action may change land values through (a) national employment and income policies which shift demand for farm products and consequently farm prices, incomes and land demand, (b) acreage control programs which directly limit land supply, (c) programs fostering creation and adoption of new technologies through research and education and (d) institutional arrangements affecting interest rates and credit supply. Government reclamation and conservation programs also influence land prices through means discussed earlier. Past and future inflationary trends may also be tied closely to actions and policies at the federal level.

Numerous other variables might be specified, but we add only the percent of forced farm sales, F, institutional credit arrangements, C, and the rate of migration from agriculture, M. It may be argued that the financial crisis of the 1930's imposed a different land price structure, an influence reflected by the percent of forced sales, F. A variable, M, representing new credit forms (e.g. land contracts), types and numbers of agencies making loans and other institutional factors was not specified in the equations but undoubtedly has had some effect on land values. High rural birth rates coupled with declining farm numbers create growing competition for existing opportunities. This influence on real estate values is summarized in the variable, M. Thus, the fifth hierarchy of variables in the price function is (15.5).

$$P = f_5(P_T, G, W, F, C, M) \tag{15.5}$$

The procedure, as stated above, was to select the one "best" variable from each hierarchy before proceeding to the next. All variables indicated in (15.1) to (15.5) were fitted, except C, M and some parts of others such as G.

Land prices do not adjust to equilibrium in the short run because of caution and inertia of past decisions, transactions too few and scattered to register a full short-run impact and for other reasons. Thus, we use the adjustment model (see model F, Chapter 10) with land price lagged one year in the following empirical section.

Least-Squares Land Price Functions

The variables in the following empirical equations are defined as follows:

P_t = the dependent variable, an index of the average U.S. farm real estate value per acre in the current year, divided by the implicit price deflator of the Gross National Product, P_G.

Y_{1t-1} = gross farm income, including government payments in the past year, deflated by P_G.

Y_{2t-1} = gross farm income, less operating and hired labor expenses of the past year, deflated by P_G.

Y_{3t-1} = gross farm income less all cash expenses of the past year, deflated by P_G.

Y_{4t-1} = gross farm income less operating and all labor expenses, machinery, livestock, feed and other asset costs of the past year, deflated by P_G. Asset costs are based on depreciation, interest and taxes; and family labor cost is based on the hired labor wage rate.

Y_{5t-1} = gross farm income less production expenses in the past year, deflated by P_G.

r_{t-1} = the rate of return on 200 (nonfarm) common stocks in the past year.

A_{t-1} = cropland acres used for crops per farm in the past year.

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

The equations are estimated from untransformed annual U.S. data from 1914 to 1960, without 1942-45. Land price and the deflator, P_G, are expressed as a percent of the 1947-49 average.

The R^2 in Table 15.2 increases from .77 to .93 when the lagged price P_{t-1} is added to (15.6), forming (15.7). However, the magnitude and significance of the A and T coefficients decline markedly. When the values in (15.7) are divided by the adjustment rate .2, the coefficients are similar, suggesting that the coefficients of A and T in (15.6) are for the long run rather than short run.

Equations (15.7) to (15.11), illustrating the results from different income variables, consistently show a rising coefficient as more inputs are subtracted from gross income. In general, the standard error also rises with the coefficient, hence the t value is not appreciably enhanced. Based on the R^2 and t tests, however, there appears to be some advantage for Y_4, the variable most closely measuring and actual return to real estate.

Excluding P_{t-1}, the variables in (15.12) are from each of the first four hierarchies previously presented. The variables from hierarchy 5 either were not significant or caused instability in other coefficients, hence were excluded.

Equation (15.13) is comparable to (15.12) with a more readily available measure of income, Y_5, substituted for Y_4. Based on the one-tailed test, the coefficients of all variables but T are highly significant in (15.13). The coefficient of T is significant at greater than the 90 percent probability level (two-tailed). The R^2 is .94, the test for autocorrelation is inconclusive at the 95 percent probability level and the coefficients display the anticipated signs. Equation (15.14) includes the same variables as (15.13) but is estimated for a shorter period, 1926-59, excluding the war years. The coefficient of income is slightly lower, of opportunity returns, r, and farm size, A, slightly higher. The differences are too small to indicate significant changes, but suggest that the importance of income may be declining relative to farm enlargement and alternative investments in determining land prices.

The coefficients in (15.13) are the basis for several inferences about the structure of land price determination over various lengths of time. The long-run coefficient of T, -2.32, suggests a secular decline in land price, currently at the annual rate of 1.8 percent. The decline probably reflects the output increasing and aggregate income depressing effects of land substitutes such as fertilizer, irrigation and other technologically improved inputs (see Chapter 5). Based on the coefficient of r in (15.13), land price is decreased only .03 percent in the short run and .14 percent in the long run by a 1 percent increase in the rate of return on an alternative investment, common stock.[3]

The estimated elasticity of land price, P, with respect to income,

[3]Computed at the 1960 observations. The respective elasticities computed at the 1914-60 means are -.08 and -.34. The long-run elasticity is the short-run elasticity divided by the adjustment rate .22.

Table 15.2. Land Price Functions Estimated With U.S. Data From 1914 to 1960, Without 1942-45; Including Coefficients, Standard Errors (in Parentheses) and Other Statistics*

Equation	R^2	d†	Constant	Y_5 t-1	Y_4 t-1	Y_3 t-1	Y_2 t-1	Y_1 t-1	r t-1	A t-1	T	P t-1
(15.6)	.767	.56	-80	.092						4.59	-2.66	
				(.050)						(.48)	(.24)	
(15.7)	.929	1.36	-23	.065						.83	-.35	.804
				(.028)						(.48)	(.28)	(.087)
(15.8)	.928	1.35	-16					.044		.73	-.41	.785
								(.020)		(.49)	(.29)	(.088)
(15.9)	.928	1.38	-21				.063			.74	-.33	.802
							(.028)			(.49)	(.28)	(.087)
(15.10)	.928	1.37	-21			.068				.74	-.33	.804
						(.030)				(.49)	(.28)	(.087)
(15.11)	.930	1.51	-23		.106					.66	-.19	.852
					(.043)					(.48)	(.28)	(.086)
(15.12)	.937	1.37	-19		.131				-1.52	.80	-.29	.840
					(.043)				(.73)	(.47)	(.27)	(.083)
(15.13) ‡	.937	1.48	-19	.088					-1.70	1.03	-.52	.776
				(.028)					(.74)	(.47)	(.28)	(.083)
(15.14) §	.942	1.55	-16	.061					-2.48	1.15	-.45	.699
				(.022)					(.65)	(.64)	(.35)	(.166)

*Variables are defined in the text; all equations are estimated from data linear in original observations.

†The Durbin-Watson d statistic.

‡In the same equation with ΔP rather than P the dependent variable, the R^2 was .44; other results were the same as in (15.13).

§Estimated linear in original observations from 1926 to 1959, excluding 1942-45.

Y_5, is .09 in the short run and .3 in the long run (15.13).[4] The adjustment coefficient, 1 minus the coefficient of P_{t-1}, or .22, indicates that 10 years are required to make 90 percent of the total desired adjustment. Thus, a 10 percent increase in net income resulting from a favorable government program, increase in demand for farm products, or from other sources, is expected to increase land values only 1 percent in one or two years and 3 percent in about 10 years. Computed from the ratio of 1960 observations, the short-run and long-run elasticities of P with respect to farm size are .61 and 2.7 respectively. Obviously, changes in farm size are predicted to strongly influence land prices. Based on the strong upward trend in farm size and the coefficient of A in (15.13), the major source of real estate price increases in the past decade has been farm consolidation and associated scale economies from larger acreages.

Trends and Projections

Figure 15.1 depicts a U-shaped trend in land prices, the low being centered in the depression years of the 1930's. By 1960, land prices in relation to other prices in the economy (represented by the implicit price deflator of the Gross National Product) were equivalent to the early 1920's price and somewhat below the 1914 and 1915 prices. The upward trend since World War II was interrupted from 1952 to 1954, but has persisted strongly since 1954 despite less favorable farm incomes.

Land values are predicted from 1914 to 1960 and projected to 1965 by equation (15.13). The projection is based on a 6 percent increase in farm size (an extension of the past rate), and on 1955-59 average net farm income, Y_5, and opportunity returns, r. The positive influence of larger farms offsets the negative influence of trend, T, and (15.13) projects an 8 percent increase in land values from 1960 to 1965. The increase is less than indicated by a linear extension of the 1956-60 trend, but is consistent with an extension of the entire postwar trend.

DEMAND FOR BUILDING IMPROVEMENTS

We now turn to analysis of a particular component of farm real estate demand, namely, farm buildings. Estimates are made by single-equation least squares. The specification of investment or demand functions follows the general formulation in Chapter 10 and the specific applications in Chapters 11 and 12, with modifications as mentioned later.

[4] These elasticity estimates are computed at 1960 values. Comparable results, .10 (short run) and .44 (long run) are found when computed at the 1914-60 means. Elasticities are more stable, of course, when computed at the means, but may not accurately reflect the current situation.

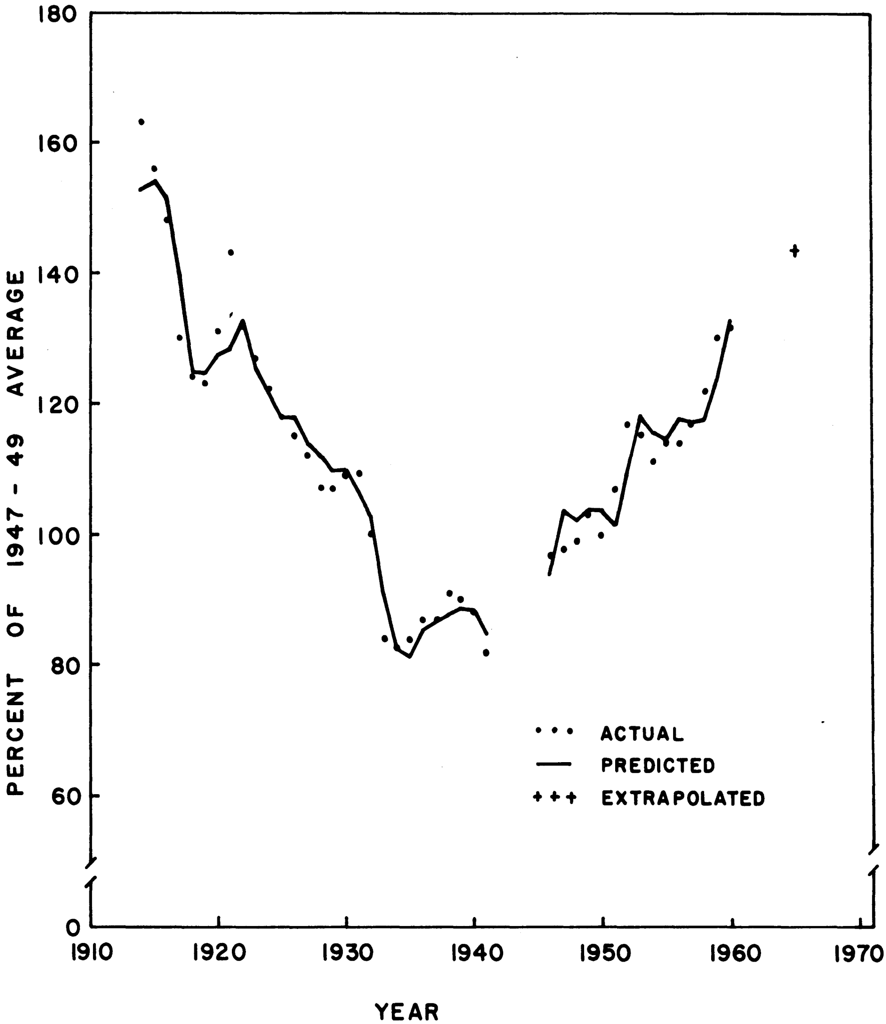

Figure 15.1. Trends in per acre real estate prices P from 1914 to 1960 (predicted and projected estimates from equation 15.13).

While virgin soil resources remained stable or declined because of cropping attrition and requirements for nonagricultural uses, the physical volume of total real estate increased 10 to 20 percent from 1926 to 1960. The increase is due largely to annual investment in building improvements, including fences, windmills and wells. In this study, the demand quantity (annual gross investment) of building materials is specified as a function of prices, beginning year stock of assets, equity,

[5]See USDA. Agricultural Research Service. Changes in farm production and efficiency. Stat. Bul. 233. 1961; The balance sheet of agriculture. Agr. Information Bul. 247 (1961) and previous issues.

net farm income, farm size, the interest rate and slowly changing influences represented by time.[6] The variables not defined earlier but included in the least-squares equations are:

Q_{BIt} = the dependent variable, the national annual aggregate expenditures on building improvements measured in millions of 1947-49 dollars, includes fences, windmills, wells and dwellings not occupied by the farm operators, deflated by prices paid by farmers for building materials.

$(P_B/P_R)_t$ = the current year index of the ratio of the price of building materials to prices received by farmers for crops and livestock.

$(P_B/P_P)_{t-1}$ = the past year index of the ratio of the price of building materials to prices paid by farmers for items used in production, including interest, taxes and wage rates.

S_{Bt} = the stock of farm buildings, excluding operators' dwellings on farms at the beginning of the current year. The variable is constructed from bench mark (census year) estimates by Tostlebe and interpolating between these bench marks from USDA data on building expenditures and depreciation.[7] The variable is in millions of 1947-49 dollars.

Variables are U.S. data from 1926 to 1959 with price indices constructed with 1947-49 = 100. Only the years 1942 to 1945 are omitted since the supply of building materials was comparatively less restricted than the supply of machinery in 1946 and 1947. Equations were estimated in original values and logarithms, but the latter were less satisfactory. Hence, all equations in Table 15.3 are in original values.

Least-Squares Demand Equations

The five independent variables in equation (15.15), Table 15.3, explain 98 percent of the variance about the mean of Q_{BIt}. Coefficients of current price, the beginning year stock of productive assets, S_p, and the equity ratio, E, are highly significant. Inclusion of net farm income, Y_F, does not improve the equation and, since E reflects the influence of income, there is no need to include both variables in subsequent equations.

Equations (15.15) and (15.16) suggest that current and past values of P_B/P_R compete in explaining the demand quantity, the significance and magnitude of the coefficient falling for the past value of price. Although the equation is useful for predicting quantities when current

[6] In addition to the demand or price function for real estate in the previous section, for further related analysis see the investment functions including buildings and other durables in Chapter 12, and the "supply" function (16.14) and discussion for farm land in Chapter 16.

[7] Tostlebe, Alvin S. Capital in Agriculture: Its Formation and Financing Since 1870. Princeton University Press. Princeton, N. J. 1957; USDA. Economic Research Service. The farm income situation. F15-183. 1961.

Table 15.3. Demand (Annual Gross Investment) Functions for Building Improvements, Q_{BI}, Estimated by Least Squares With U.S. Data From 1926 to 1959, Omitting 1942 to 1945; Including Coefficients, Standard Errors (in Parentheses) and Related Statistics*

Equation, and Model†	R^2	d‡	Constant	P_B/P_R t	P_B/P_R t-1	P_B/P_P t-1	S_P t	E t-1	Y_F t-1	Y_{DF} t-1	T	Q_{BI} t-1	S_B t
(15.15) AB	.98	1.48	-895.83	-3.58			18.69	59.22	-.0058		-5.05		
				(.77)			(2.04)	(10.03)	(.0100)		(3.00)		
(15.16) B	.96	1.18	-923.30		-2.52	.57	15.86	56.79			-4.02		
					(.91)	(3.56)	(4.01)	(10.68)			(6.33)		
(15.17) B	.98	1.58	-990.70	-3.27			19.04	54.65			-5.27		
				(.55)			(2.84)	(6.15)			(2.94)		
(15.18) A	.94	1.77	-1631.95	-2.44			21.76		.0406		-.47		
				(1.14)			(4.44)		(.0096)		(4.45)		
(15.19) A	.97	1.45	-1659.44	-2.18			21.68			.0482	-2.56		
				(.77)			(3.34)			(.0068)	(3.30)		
(15.20) BF	.95	1.29	76.71	-2.35				31.81			6.91	.39	
				(.75)				(10.99)			(2.81)	(.11)	
(15.21) F	.94	1.53	-45.16	-2.30					.021		9.70	.54	
				(1.14)					(.011)		(2.95)	(.11)	
(15.22) BG	.97	1.42	-289.21	-3.24				59.40			2.16		.060
				(.58)				(6.56)			(2.40)		(.010)
(15.23) G	.93	1.45	-828.20	-2.42					.043		9.60		.063
				(1.25)					(.011)		(3.39)		(.016)

*The dependent variable, Q_{BI}, and the indicated independent variables are defined in the text and in Chapter 11. All equations are estimated linear in original data.

†Expectation and adjustment models are presented in Chapter 10.

‡The Durbin-Watson autocorrelation statistic d.

price is unavailable, it may result in some bias. We select to include only current price and to interpret the coefficient as the influence of both current and past prices. Equation (15.17) is equation (15.15) with the nonsignificant income variable omitted.

Equations (15.18) and (15.19) indicate the influence of past income on annual investment in building improvements. The coefficient of income increases from .041 to .048 as additional lagged values of income are included. The small size of the increment indicates that additional lags add little to the coefficient of income.

Some support for using an adjustment model to represent annual gross building investment is provided by (15.20) and (15.21). If expectations are specified as in (15.20), the adjustment apparently is very rapid — about 60 percent in the short run. The magnitude implies that the adjustment of annual purchases to desired levels occurs quickly, but does not indicate the speed of adjustment to the desired level of stock. Inclusion of lagged building stock in investment equation (15.22) improves the fit over (15.20) and allows approximate determination of the adjustment coefficient. The coefficient of lagged stock is positive and highly significant. Because it is the depreciation coefficient, h, less the adjustment coefficient, g, (see model G, Chapter 10), it indicates h exceeds g by .06. The exact depreciation rate is unknown but probably is considerably below the machinery depreciation rate. If the depreciation rate were .10, the adjustment rate would be .10 -.06 = .04, a slow rate of adjustment indeed. Since the depreciation rate is low, a large number of years may pass before the equilibrium stock is reached, i.e. where $Q_{BI} = h\, S_B$.

The R^2's are somewhat lower and evidence of autocorrelation is higher for adjustment equations (15.20) and (15.22) than for the previous conventional equation (15.17). Two additional variables, cropland acres per farm and the short-term interest rate, were included in an equation with P_B/P_R, S_p, E and T. The coefficients of both added variables statistically were insignificant, and the equation is not included in Table 15.3.

Price and Income Elasticities of Demand

Computed from (15.17), the short-run elasticity of Q_{BI} with respect to $(P_B/P_R)_t$ is -.88. A sustained 1 percent increase in net income raises E by 1.57 percent according to equation (11.15). Using this relationship, the elasticity of Q_{BI} with respect to net income is 1.30. If a 1 percent increase in P_R/P_P increases net income 2 percent, the long-run elasticity of demand for Q_{BI} with respect to P_R is .88 (from $(P_M/P_R)_t$) plus 2.60 (from E), or 3.48. The elasticity is computed at the means of the variables for the 1926-59 period.

The result suggests that investment in real estate improvements is more responsive than investment in machinery to long-run price changes (see Chapter 11). Average annual investment in building improvements is a small proportion of building stock because depreciation (replacement requirement) is low. A large percentage change in annual investment is required if only a small increase in stock is desired. This structure perhaps explains the high elasticity of annual investment, particularly of annual investment in building improvements. Three or four years after a sustained 1 percent rise in prices received by farmers, annual investment is predicted to be more than 3 percent above the initial investment according to the above results. The depreciation rate and pattern of resource use is such that farmers may easily postpone investment in real estate improvements in unfavorable years without seriously reducing production. In favorable years the opportunity and need to expand investment in building improvements are great, partially because an improved financial situation permits purchase of building improvements (which are a major nondivisible expenditure in many instances) and also because a backlog of improvements may have developed during depressed periods.

Since annual investment tends to be a small proportion of the stock of buildings on farms, the elasticity with respect to S_B is much below the above estimates. The elasticity of S_B with respect to $(P_B/P_R)_t$ from equation (15.22) is only -.06. The intermediate-run elasticity (four or five years — after Q_{BI} has reached the desired level) of S_B with respect to P_R is .14, computed from the same equation. In spite of the elastic demand for Q_{BI}, a sustained 1 percent increase in P_R would increase building stocks only .14 percent in about four years based on the above estimate. If the adjustment coefficient is .04, the long-run elasticity of stock with respect to P_R is 3.5. The "long-run" is indeed long; more than 50 years are required to make 90 percent of the desired adjustment! Since the data are subject to large errors, the above results should be considered hypotheses for further testing, rather than as conclusive estimates.

Shifts in Demand

In 1959, annual gross investment in building improvements was 140 percent above the 1926 level. Equation (15.17) is used as a basis for estimating the sources of this increase in annual investment. Three possible sources are: (a) prices, P_B/P_R, (b) earnings and equity, E, and (c) structure, S_p and T. Because of the correlation between S_p and T, it is advisable to give the variables a joint interpretation. If these variables are given 1959 values, (15.17) predicts that demand would have been 155 percent greater than in 1926. Hence, some discrepancy exists between the actual and predicted changes in demand quantity. If price, P_B/P_R, has been at 1959 level in 1926, other things equal, the predicted demand quantity would have been 50 percent <u>less</u> than the actual demand in 1926 according to equation (15.17). If earnings and equity had been at the 1959 value in 1926, the predicted demand quantity would have been 100 percent above the 1926 level, other things being equal.

Because other input prices fell and because efficiency increased, farmers apparently improved their financial status sufficiently to increase purchases of building improvements by a sizeable amount. The influence of both price and equity would increase demand by a net of about 50 percent. Hence, the remaining portion of the total 140 percent increase remains to be explained by structural changes. Included in structural changes are a broad range of physical and technological influences. Examples are the large building investment needed to store and house increased inventories of livestock and feed.

Technological influence may not be as dramatic as for farm machinery. Nevertheless, changes in methods of storing feeds, handling dairy cattle, etc. have influenced demand for buildings. Influences tending to reduce farm numbers and replace labor with other resources also have created an impact on the investment in real estate improvements. Some of these influences reduce demand, others increase demand, but the net influence according to (15.17) is to shift demand to the right approximately 2 percent per year. Buildings themselves (e.g. loose housing as compared to stanchion arrangements for cows or silos for storing green cut forage as compared to barn storage) are substitutes for labor. We have not, however, established these relationships in this study.

Trends and Projections

Investment in building improvements fell appreciably in the depression years, then recovered in the late 1930's but not to the immediate predepression level (Figure 15.2). Annual investment in the postwar period was on a totally higher plane than during the prewar period. As the backlog of demand created by depreciated stocks, latent technology, rationing of material and improved farm financial situation was filled, the demand quantity declined in the mid 1950's. There is some evidence that the downward trend is slowing.

Equation (15.19) is used for prediction. Statistically it appears to be one of the better estimates, but some large ex post errors are apparent. Gross investment, Q_{BI}, is projected to 1965 from the equation assuming that farm income will be at the 1955-59 level. Prices of building improvements have not increased as much as machinery but, based on past trends, P_B/P_R is set 5 percent above the 1960 level. Using these values and S_p = 112.4 billion 1947-49 dollars from equation (12.23), the projected quantity of Q_{BI} is 7 percent above the predicted value for 1960. The projection suggests a reversal of the downward trend in purchases, but alternative assumptions about prices and incomes could yield different conclusions.

FARM NUMBERS

Changes in farm size and numbers have been closely identified with

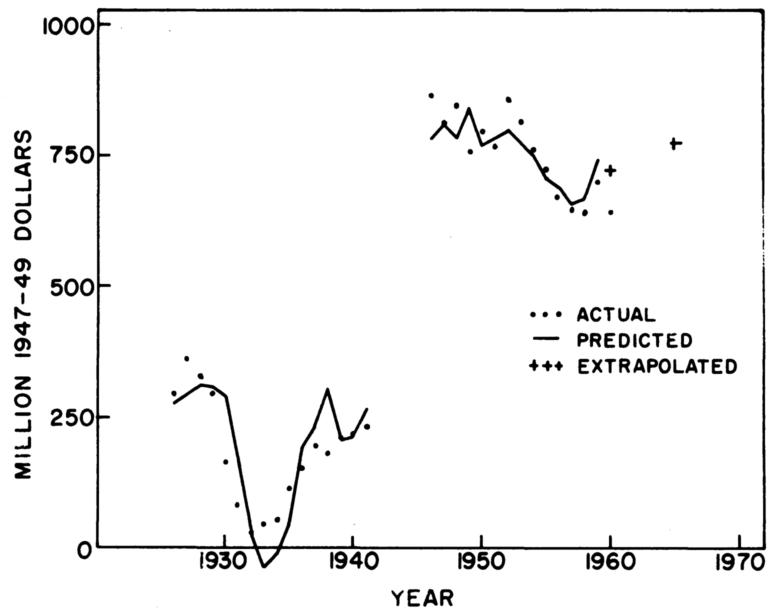

Figure 15.2. Trends in purchases of building improvements Q_{BI} from 1926 to 1960 (predicted and projected estimates from equation 15.19).

dynamic trends in the resource structure of agriculture. (Farm size and numbers essentially are equivalent concepts since total acreage has been quite fixed.) Farm numbers grew 6 percent from 1910 to 1935.[8] It is interesting to note that the peak year for farm numbers, 1935, also is a bench mark for the beginning of the major technological revolution in farm input structure. It was after 1935 that the major substitution of purchased for farm-produced inputs took place, and the rapid upward trend in the output-input index began. By 1960, farm numbers were much below the 1935 peak, and the decline is certain to continue.

In Chapters 3 and 11 we emphasized the interrelationships of farm size and machinery demand. It also may be stated that forces determining farm numbers and size of the family work force are almost equivalent. Since agriculture is geared to a family farm organization,

[8] Economic report of the President. U.S. Government Printing Office. Washington, D.C. 1961. The "old" definition of a farm is used in this chapter because "new" data were not available when the analysis was made. The two measures, discussed more extensively in Chapter 18, are similar to 1940 but the "old" measure is greater after 1940. The measure in this study comprises all farms and hence includes many small acreages with a minor portion of income from farming. These small units more realistically might be classified as urban units. Unfortunately, annual data necessary for regression analysis are not now available for a more sensible breakdown of farm numbers into size and income classifications. It is hoped that although the measure used in this study tends to overestimate total farm numbers, it is a reasonable approximation of relative changes in numbers.

a reduction in family workers tends to be reflected in farm numbers. Government programs to increase family labor mobility are almost synonymous with programs to reduce farm numbers. These considerations suggest a specification of farm numbers function equivalent to that for family labor in Chapter 9. We review briefly that model (15.24) where N is farm numbers, Y_R is the ratio of factory to farm income per worker, U is the national unemployment rate and V is the critical rate of unemployment at which changes in Y_R no longer are effective in adjusting the work force between sectors, and mobility between the farm and nonfarm sector ceases.

$$N_t = a - b[Y_R(1 - U/V)]_{t-1} - c\, S_{Mt} \tag{15.24}$$

S_M is the stock of farm machinery on January 1. Multiplying the bracketed term by b, the model (15.25) is suitable for least-squares estimation.

$$N_t = a - b\, Y_{Rt-1} + \frac{b}{V}(U\, Y_R)_{t-1} - c\, S_{Mt} \tag{15.25}$$

An estimate of V is found by dividing the coefficient of Y_R by the coefficient of $U\, Y_R$. We may interpret the above model as explaining farm numbers by the "pull" and "push" hypotheses. More favorable nonfarm incomes indicated by Y_R "pull" family workers to nonfarm employment, subject to the restraints of the national unemployment, U. Higher stocks of machinery, S_M, tend to "push" workers from agriculture and reduce farm numbers by decreasing labor demand and creating pressures for worker exodus and farm consolidation. The logic of other variables specified in the farm numbers functions is discussed in Chapter 9.

The variables are defined explicitly as:

N_t = the dependent variable, the average number of all U.S. farms in the current year, expressed in thousands.

Y_{Rt-1} = the past year index of the ratio of average annual wages per employed factory worker to the net farm income per family worker in agriculture, 1947-49 = 100.

U_{t-1} = the proportion of the total national work force unemployed in the past year.

S_{Mt} = the stock of all machinery (40 percent of auto stock) on farms January 1 of the current year.

E_{t-1} = the past year ratio of owners' equity to all farm debts.

G_t = an index of current government programs.

The above variables and time, T, extend from 1926 to 1959, excluding the war years 1942 to 1945. All equations are estimated only in original observations.

Table 15.4. Farm Number Functions Estimated by Least Squares With U.S. Data From 1926 to 1959, Without 1942-45; Including Coefficients, Standard Errors (in Parentheses) and Related Statistics*

Equation	R^2	d†	Constant	Y_{R_t}	$Y_{R_{t-1}}$	UY_{R_t}	$UY_{R_{t-1}}$	E_{t-1}	S_{M_t}	G_t	T	N_{t-1}
(15.26)	.963	.89	9052		-6.59 (1.52)		25.81 (3.43)	22.68 (17.13)			-62.35 (4.47)	
(15.27)	.966	.66	8708		-5.24 (1.79)		19.39 (5.02)		-.052 (.028)		-45.32 (7.21)	
(15.28)	.965	.96	9031		-6.65 (1.41)		26.20 (3.32)			6.24 (3.60)	-59.01 (2.85)	
(15.29)	.961	.90	9131		-7.54 (1.36)		26.48 (3.44)				-57.77 (2.86)	
(15.30)	.965	1.05	9328	-9.02 (1.26)		28.02 (3.22)					-57.81 (2.75)	
(15.31)	.996	2.11	1851		-1.39 (.626)		5.71 (1.85)				-14.05 (3.19)	.801 (.056)
(15.32)	.996	2.22	2136	-2.16 (.67)		6.97 (1.92)					-15.48 (3.26)	.780 (.057)

†The Durbin-Watson statistic d.

Farm Numbers Estimated by Least Squares

Equations (15.26) to (15.28), Table 15.4, illustrate the statistical influence of E, S_M and G on farm numbers. The coefficients possess the anticipated signs, but each is less than twice the standard errors. When these variables are included in equations along with the lagged dependent variable, the coefficients are much less significant and hence the variables are not included in the last two equations of Table 15.4. The influences represented by the excluded variables are often confounded with other variables, and their total influence perhaps can only be represented by time, T.

The coefficients of the three independent variables in equations (15.29) and (15.30) are highly significant, but the hypothesis of zero autocorrelation is rejected. Adjustment equations (15.31) and (15.32), formed by adding N_{t-1} to the preceding equations, seem appropriate not only on a priori grounds, but also because of favorable statistical properties. Autocorrelation is not evident, the R^2 is increased and all coefficients are significant in the latter equations. Comparisons of coefficients in the conventional and adjustment equations suggest that the coefficients in (15.26) to (15.30) are long run rather than short run. That is, the long-run coefficients in (15.31) and (15.32), found by dividing the short-run coefficients by the adjustment rate .2, are somewhat comparable to the coefficients in the conventional equations.

Equations including current rather than past year income and unemployment variables give slightly larger and more significant coefficients. Collinearities preclude isolation of the separate influences of current and past year income, Y_R, on N; therefore, coefficients of either are called "short run." Combining the current unemployment variable with past income (U_t Y_{Rt-1}) in an equation similar to (15.31), and other "refinements" did not improve results; hence, these modified equations are not included in Table 15.4.

Table 15.5. Elasticities of Farm Numbers, N, With Respect to the Factory/Farm Worker Income Ratio, Y_R, Computed at the 1926-59 Means From Equation (15.31)*

Unemployment (percent) †	Short Run (1-2 years)	Long Run (about 10 years)
0	-.034	-.171
5	-.027	-.136
10	-.020	-.101
15	-.013	-.066
20	-.006	-.030
25	.001	.005

*The elasticities with respect to nonfarm wages have the signs indicated; with respect to per worker, farm incomes are opposite the signs indicated.

†The 1960 unemployment rate was 6 percent, and the 1946-59 average was 4 percent.

Elasticities With Respect to Income

The long-run influence of machinery investment and other factors embodied in the time variable annually reduce farm numbers by 70,000 according to (15.32). Since farm numbers were 4.5 million (old definition) in 1960, the reduction that year would have represented 1.5 percent of all farms.

The influence of wage and employment structure on farm numbers is illustrated in Table 15.5. The elasticity of N with respect to Y_R is low in all cases but reaches zero when U is 24 percent. Under the

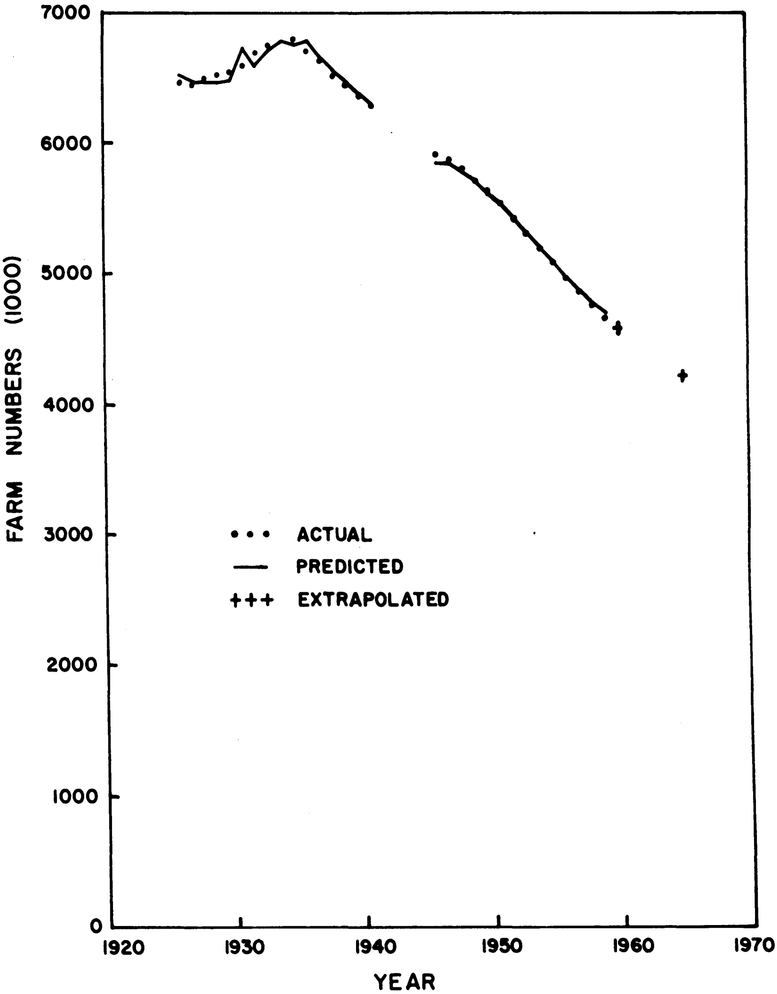

Figure 15.3. Trends in farm numbers N from 1926 to 1960 (predicted and projected estimates from equation 15.31).

most favorable employment conditions, a sustained 10 percent increase in nonfarm income reduces farm numbers .3 percent in one or two years and 2 percent in roughly 10 years. The impact of higher unemployment on labor mobility and farm numbers becomes greater as the rate of unemployment rises. For example, a drop in unemployment from 20 to 15 percent increases the elasticity over 100 percent, but a drop from 10 to 5 percent increases the elasticity only 35 percent.

Trends and Projections

The stable downward trend (Figure 15.3) in farm numbers since 1936 explains why some R^2's were more than .99 in Table 15.4. A simple linear function would fit the data very well since that date. Equation (15.31) predicted 4.6 million farms in 1960; the actual number was 4.5 million. Projecting farm numbers to 1965 from average 1955-59 income and employment data, equation (15.31) indicates 360 thousand fewer farms than in 1960. The projection, 4.2 million farms, is nearly 8 percent below the 1960 number.[9]

Again, inferences are subject to the data limitations. The uniform trends in Figure 15.3 to some extent arise from insufficient yearly data; e.g., some of the published annual estimates may reflect a simple interpolation between bench mark census years. We hope, nevertheless, that the income elasticities have sufficient validity to be of some use in converting income projections such as those made in the following chapter to a per farm basis.

[9] The latest estimate of 1960 farm numbers is 3.95 million, or .6 million less than the old estimate, 4.54 million, used above. Projected 1965 numbers would also have to be adjusted accordingly. The number projected to 1965 would be considerably less under the new definition, because it depicts a more sharply falling trend after the war.