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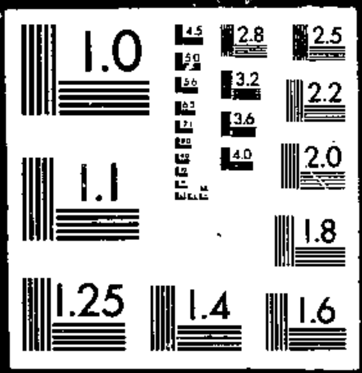

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James Hrubovcak and Michael LeBlanc

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Keywords: Tax policy, agricultural investment, equipment investment, structure investment.

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Contents

	Page
Summary	iv
Introduction	1
Income Tax and the Rental Rate of Capital	1
The Investment Model	3
Data	6
Estimated Model	7
Tax Policy Effects	9
Investment Tax Credit	9
Interest Deductibility	11
Pre-1954 Tax Laws	12
Conclusions	12
References	13

Summary

Tax policies between 1956 and 1978 stimulated net investment in agricultural equipment by more than $5 billion and net investment in agricultural structures by more than $1 billion (1977 dollars). Not only has tax policy led to increased investment in agricultural equipment and structures, it also has increased potential output in the agricultural sector. Attempts to restrict agricultural output and support farm income, the goal of farm commodity policies, may have been offset by investment stimulated by changes in tax policy.

This technical study assessed three tax alternatives: the investment tax credit, the deductibility of interest expenses, and the interaction of all new tax provisions enacted since 1954. The results suggest that the investment tax credit has probably been the most effective tool in stimulating investment. From 1962 to 1978, for example, the investment tax credit accounted for nearly $3 billion, or 12 percent, of net investment in total agricultural equipment and $500 million, or 5 percent, for structures.

Tax Policy and Agricultural Investment

James Hrubovcak
Michael LeBlanc*

Introduction

Tax policy has been used extensively to promote capital formation in the United States since the early fifties. Manipulating the tax code to induce investment was an outgrowth of experience gained during World Wars I and II when accelerated depreciation was used to encourage plant expansion for the production of war output (*6*).[1]

Throughout the fifties and sixties, the effectiveness of tax policy to alter investment behavior was accepted as an article of economic faith. Firms would purchase more capital goods if those goods cost less, according to this reasoning. This argument is compelling but incomplete, for it fails to address the question of the magnitude of investment's response to increases in profitability. Hall and Jorgenson were the first to study the relationship between tax policy and nonfarm business investment (*16*). They concluded "tax policy is highly effective in changing the level and timing of investment expenditures."[2] They found, for example, that 41 percent of the investment in manufacturing equipment in 1963 was attributable to the investment tax credit.[3]

If these results can be extended to the agricultural sector, they have important implications for food policy as well as fiscal policy. Increases in agricultural investment in general expand the production capacity of the food and fiber sector and induce productivity growth by acting as a medium for technological change. As tax policy has expanded investment, raised production, and lowered prices, it has contradicted other agricultural policies.

This paper examines the effects of taxes on investment in agriculture, thereby assessing the potentially contradictory character of tax and farm policy. The authors separated agricultural capital into four asset classes: short-lived equipment, long-lived equipment, structures, and land. The authors also examined the effects of investment tax credits, interest deductibility, accelerated depreciation, and liberalized amortization on these four asset classes for the period 1955-78.

The effects of tax policies on agricultural investment are examined by placing the investment decision in a theoretical framework where the optimal levels of all variable and quasi-fixed inputs are determined simultaneously. Results from duality theory on restricted variable profit functions are incorporated into a dynamic optimization framework where input use is affected by external adjustment costs (*10, 26, 44*). An approximation to this "third generation" dynamic framework is used to estimate the structure of the investment functions for the four asset classes.[4] Each investment equation is a function of variable input and output prices, technological change, rental rate for capital, and lagged capital stock. Changes in tax policies affect investment by altering the rental rate of capital. Results from this analysis suggest tax policies are effective in promoting agricultural investment.

Income Tax and the Rental Rate of Capital

The critical role of the rental rate of capital and the financial policy of the firm is well illustrated by the "Marshallian" view of income taxes falling on pure profits.[5] The Marshallian view is that a profits tax does not affect output in either the short run or long run.

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[1]Italicized numbers in parentheses refer to literature cited in the References section of this report.

[2]For critiques of this analysis see Coen (*8*) and Eisner (*9*).

[3]Seemingly contradictory findings are provided by Auerbach and Summers who state, "There is little evidence that a change in the investment tax credit is an effective tool for expansionary fiscal policy. . . . We are skeptical of its longrun effect on capital accumulation" (*2*).

[4]Berndt, Morrison, and Watkins categorize dynamic models as belonging to either the first generation (single-equation models using a Koyck partial adjustment framework) (*23*), second generation (allowing input interaction, but only a limited theoretical basis for the adjustment process), or third generation (explicitly incorporating dynamic optimization) (*5*).

[5]For a more detailed discussion of this point, see Atkinson and Stiglitz (*1*) and Robertson (*32*).

Because taxes are levied (at rate T) on net profits, firms receive

$$\pi = (1 - T)(PQ - wL - uK) \qquad (1)$$

where PQ is revenue, w is the wage rate, L is the quantity of labor, u is the rental rate, and K is the quantity of capital. Tax rates do not affect the shortrun first-order conditions for capital and labor. In the longer run, entry and exit are determined by the marginal firm which by definition is making zero profits. Longrun output is, therefore, also unchanged.

This Marshallian view of taxes depends on the assumption that the tax base (revenue less cost) excludes the cost of capital (uK). The key to levying neutral income taxes by taxing authorities is therefore in the definition of the tax base. The failure to accurately identify the tax base leads to input and output distortions.

Nonneutral tax-induced changes in rental rates affect the capital stock because lower taxed capital inputs are substituted for higher taxed capital inputs or by replacing capital more rapidly than before the tax changes. Assuming perfectly competitive market conditions and a cost-minimizing profit-maximizing behavior, firms adjust their stocks of inputs until the ratio of marginal products of any pair of inputs is equal to the ratio of their respective rental rates. To the degree that inputs are substitutable, a change in tax law which results in a decrease in the rental rate of one input relative to other inputs increases the demand for the lower priced input until the cost minimization conditions are satisfied. Conversely, an increase in the rental rate of one input relative to other inputs will decrease the demand for the higher priced input. The same tax treatment is not necessarily appropriate for each type of asset. In the presence of an otherwise neutral income tax system, inflation can bias the mix of inputs that is employed. Because tax depreciation deductions are based on the historical cost of assets, inflation reduces the real value of the nominal deductions, with the reduction being the greatest for shorter lived assets (*19*). During times of inflation, the use of historical cost tax depreciation for all assets would result in an increased demand for longer lived assets relative to assets with shorter lives.

For the past 30 years, income tax policy has significantly affected the definition of the tax base. In 1954 and again in 1962, amortization of capital expenditures was liberalized by providing for faster writeoffs. Also in 1962, a 7-percent investment tax credit was instituted for qualifying plant and equipment. This tax credit was eliminated in 1969, restored in 1971, and increased to 10 percent in 1975. The asset depreciation range (ADR) system instituted in 1971 and the Economic Recovery Tax Act of 1981 both shortened tax lives.[6]

The rental price of a unit of capital services is the after-tax cost of those capital services internally supplied by the firm. When a firm leases capital services, the rental rate is the price the firm will charge for each unit of capital service leased. Therefore, the rental rate is the rate the firm must charge in order to earn the required after-tax rate of return. The rental rate is a function of the price of the asset, the rate of capacity depreciation, the tax variables, the discount rate, and the rate of inflation. True rental rates are directly observed from market transactions with active rental markets. Implicit rental rates are estimates of the true rental rates that would prevail under given sets of assumptions.

A formula for implicit rental rates is developed from the equality between the purchase price of the asset and the present value of the future rents generated by the asset (*22*). Assuming constant new asset price expectations and allowing for alternative depreciation patterns, the basic relationship is

$$\hat{q}_i = \int_0^{L_i} e^{-rt} u_i n_i(t)\, dt \qquad i = 1,2,\ldots,m. \qquad (2)$$

where $\hat{q}_i$ is the purchase price of the ith asset when new, L_i is the service life, u_i is the rental rate expressed in terms of an undepreciated unit of capital, $n_i(t)$ is the capacity of the asset available in year t of its service life, and r is the discount rate.

Equation (2) ignores all tax considerations. When capital income is subject to an income tax, the term on the right side of equation (2) is modified to include the effects of the tax. The modified term includes the present value of the rents generated by the asset, and the present value of the tax savings produced by the investment tax credit and the tax depreciation deductions. Assuming the firm's marginal tax rate remains constant at T, equation (2) is respecified to accommodate the tax system

$$\hat{q}_i = (1 - T)u_i N_i + \Theta_i \hat{q}_i + T(1 - h\theta_i) Z_i \hat{q}_i \qquad (3)$$

$$i = 1,2,\ldots,m.$$

where $(1 - T)u_i N_i$ is the present value of the future rents, $\Theta_i \hat{q}_i$ is the present value of the investment tax credit, and $T(1 - h\theta_i) Z_i \hat{q}_i$ is the present value of the future tax depreciation deductions.

[6] This analysis does not seek to detail each of these tax provisions. Instead, only the key features affecting investment decisions are captured within a stylized rental rate for capital.

If price expectations and the marginal tax rate are constant, the implicit rental rate remains constant over the life of the asset. The capacity of the asset, however, declines over the life of the asset so that

$$N_i = \int_0^{L_i} e^{-rt} n_i(t)\, dt \qquad i = 1,2,\ldots,m. \tag{4}$$

where r is the discount rate, the real after-tax rate of return required by the firm.

Although the firm pays taxes on the rents generated by each asset, the firm can deduct the decline in the value of the asset as an expense. If the present value of the depreciation deductions claimed for tax purposes is equal to the true decline in capacity for each asset, the tax system does not distort the asset mix.

If $z_i(t)$ is the fraction of the price of the ith asset deducted from income in year t of the asset's tax life (M_i), the present value of the tax depreciation is $TZ_i\hat{q}_i$, where

$$Z_i = \int_0^{M_i} e^{-(r+p)t} z_i(t)\, dt \qquad i = 1,2,\ldots,m. \tag{5}$$

and p is the rate of inflation. However, in years when the tax depreciation base was reduced by the amount of the investment tax credit, the real value of the tax depreciation deduction is $T(1 - h\theta_i)Z_i\hat{q}_i$, where h is the percent of the credit which reduces the depreciation base.

In addition to the depreciation deductions, firms may also be eligible to claim an investment tax credit. If firms claim the credit at the end of the first year of the asset's service life, the present value of the credit is $\Theta_i\hat{q}_i$, where

$$\Theta_i = e^{-(r+p)t}\theta_i \qquad i = 1,2,\ldots,m. \tag{6}$$

A more realistic rendering of the discount rate shows it as a weighted average of the longrun real after-tax interest rate (external financing) and the longrun real after-tax return to equity (internal financing). Because nominal interest charges are deductible from taxable income, the real cost of external or debt financing (r_d) is

$$r_d = [r_n(1 - T) - p]/(1 + p) \tag{7}$$

where r_n is the nominal interest rate. After combining the real costs of both equity and debt financing, the real cost of capital or real after-tax discount rate is

$$r = fr_d + (1 - f)r_e \tag{8}$$

where f is the fraction debt financed, r_d is the real after-tax cost of debt financing, and r_e is the real after-tax return to equity (*34*).

The effects of State and local property taxes on the rental rate can be incorporated directly into the discount rate (*19*). Because property taxes are generally levied in the current year but payable in the next year and property taxes are deductible from the Federal income tax, equation (8) is recast as

$$r = fr_d + (1 - f)r_e + [(1 - T)S/(1 + p)] \tag{9}$$

where S is the property tax rate expressed as a percentage of the value of the asset.

Given the market price of the asset, equation (3) is rewritten as

$$u_i = \hat{q}_i[1 - \Theta_i - T(1 - h\theta_i)Z_i]/N_i(1 - T) \tag{10}$$

$$i = 1,2,\ldots,m$$

which is the rental rate the firm must charge to earn the required real after-tax rate of return. Increases in the real values of the investment tax credit or tax depreciation deductions resulting from changes in tax laws or reductions in the inflation rate decrease the rental rate. A tax rate reduction decreases the tax on the rents generated by the asset, but also reduces the value of the tax depreciation deductions. Reducing the marginal tax rate can only cause higher rental rates if the real after-tax depreciation deductions are greater than the net of credit purchase price. Such a situation implies a negative implicit rental rate.

The Investment Model

Economists have sought a theoretical framework for the partial adjustment or accelerator model since Nerlove's early applied work (*29, 30*). Many economists recognized a gap in econometric theory where an elaborate theoretical structure, which existed for determining the level of an input, was combined with an ad hoc theory of adjustment. Eisner and Strotz developed a more rigorous theory of adjustment by casting the firm in a dynamic optimization framework (*10*). The present value or net worth maximized by the firm depends on the optimal level of inputs selected by the firm and on the path of the current capital stock to the optimal level.

More recently, Lucas (*26*), Gould (*15*), and Treadway (*35*) have extended the work of Eisner and Strotz.

Although the models differ in their complexity, they all have the same underlying structure postulated by Eisner and Strotz. Each specifies an objective function incorporating factor adjustment costs and a production function. The firm is assumed to maximize net worth over a given time period. Adjustment costs are interpreted either as foregone profits due to shortrun rising supply prices in the capital-supplying industry or as increasing costs associated with integrating new equipment into production (reorganizing production and training workers). These costs vary with the speed of capital adjustments. It is also assumed that the values of the expected input and output prices do not change. This static or stationary expectations assumption is required if the dynamic maximization problem is to be well defined (*31*).[7] Because expectations are static, the firm adjusts to a fixed target considered to be the longrun equilibrium of neoclassical theory. Given these assumptions, a firm maximizing its present value changes capital stock in a manner similar to that suggested by the accelerator model.

Following Berndt, Fuss, and Waverman (*4*) and Berndt, Morrison, and Watkins (*5*), the optimal adjustment paths for the quasi-fixed inputs are derived by incorporating a shortrun restricted profit function into a longrun dynamic optimization framework. The assumptions of competitive input and output markets are maintained. In addition, it is assumed that these competitive real prices are known with certainty and remain stationary over time.

In the usual Marshallian framework the relative fixity of inputs slows adjustment to a new equilibrium position. Immediate adjustment is prevented because certain inputs cannot be changed until a given period of time has elapsed after the original decision to alter the inputs is made. If uncertainty is excluded, then the reason for slower rather than faster adjustment is that it costs the firm more to adjust production more rapidly. Following Eisner and Strotz (*10*), production factors are characterized as being more or less fixed as a function of the cost of varying the input sooner rather than later.

Such a framework assumes that quasi-fixed inputs can be varied at a cost $C_i(\dot{K}_i)$ where $\dot{K}$ equals dK/dt. That is

$$\dot{K}_i = I_i - \delta_i K_i \qquad i = 1,2,\ldots,m \tag{11}$$

where I_i is the gross addition to the stock of factor i and δ_i is the rate of exponential depreciation. Also, the cost of adjustment is defined as

$$\hat{C}_i(\dot{K}_i) = \hat{q}_i I_i + \hat{q}_i D_i(\dot{K}_i) \qquad i = 1,2,\ldots,m \tag{12}$$

where $\hat{q}_i$ is the purchase price of asset i, $D_i(\dot{K}_i)$ is a twice-differentiable function, and $D_i(\dot{K}) > 0$. Adjustment costs at the initial time t = 0 are

$$\hat{C}_i(0) = \hat{q}_i \delta_i K_i \qquad i = 1,2,\ldots,m \tag{13}$$

this formulation assures constant marginal costs of replacement with increasing marginal costs of net change. Costs are expressed in units of the asset price of the quasi-fixed factors.

Net receipts $\hat{R}(t)$ can, therefore, be written as

$$\hat{R}(t) = PG(W,K) - \sum_{i=1}^{m} \hat{C}_i(\dot{K}_i) \tag{14}$$

where P is the unit price of output, G(W,K) is the Unit-Output-Price (UOP) restricted profit function, W is a vector of normalized (output price) input prices, and K is a vector of quasi-fixed capital inputs.[8]

If the firm requires a rate of return r, a weighted average of the rate of return to equity, and the cost of external financing, then the present value of net receipts at time t = 0 is

$$V(0) = e^{-rt} \int_0^\infty \hat{R}(t)dt. \tag{15}$$

The firm's longrun dynamic problem is to choose time paths for variable inputs, X(t), and quasi-fixed inputs, K(t), to maximize V(0) given K(0) and X(t), K(t) > 0. Because G assumes shortrun optimizing behavior conditional on P, W, and K, the optimization problem facing the firm is to find among all the possible G(W,P) combinations, the time paths of X(t) and K(t) that maximize the present value of net receipts.

A solution to (15) can be obtained by using either the Euler equation or Pontryagin's maximum principle. If static price expectations are assumed and profits and adjustment costs are normalized on output price, then

[7]It is likely that this assumption could be relaxed if a more general approach to the formation of expectations were allowed. For a comparison of a subjective Bayesian concept of rational expectations see Swamy, Barth, and Tinsley (*33*).

[8]The restricted profit function represents the locus of shortrun maximized profit of a firm as a function of output price, input prices, and quantities of fixed factors (*30*). The profit function is nondecreasing in P and nonincreasing and convex in W (normalized input prices) and nondecreasing in P and K.

the Hamiltonian necessary for applying the maximum principle is

$$H(X,K,\dot{K},y,t) = e^{-rt}(G(W,K(t)) - \sum_{i=1}^{m} C_i\dot{K}_i(t)) + \sum_{i=1}^{m} y_i\dot{K}_i(t) \qquad (16)$$

where y_i are costate variables, the dynamic equivalent of the Lagrange multipliers of static optimization problems and C_i is the normalized adjustment cost. Costate variables generally vary through time and are assumed to be nonzero continuous functions of time (*18*). Necessary conditions for the maximization of H require

$$G_i'(W,K) - u_i - rC_i'(\dot{K}_i) + C_i''(\dot{K}_{ii})\ddot{K}_i = 0 \qquad (17)$$
$$i = 1,2,\ldots,m.$$

These necessary conditions are assumed sufficient to obtain a maximum. That is, the marginal profit associated with the ith quasi-fixed input equals its marginal cost of adjustment. Equation (17) has a stationary solution $K^*_i(P,W,r)$ which is obtained by setting $\dot{K}_i = \ddot{K}_i = 0$

$$G_i'(X^*(K^*), K^*) - u_i - rC_i'(0) = 0 \qquad (18)$$
$$i = 1,2,\ldots,m.$$

The variable K^* is the steady-state or longrun profit maximizing demand for the vector of quasi-fixed factors obtained by solving equation (18).

These results are linked to the partial adjustment or flexible accelerator literature because the shortrun demand for the quasi-fixed factors can be generated from equations (17) and (18) as an approximate solution in the neighborhood of $K^*(t)$ (*24*). The approximate solution is the linear differential system

$$\dot{K} = B(K^*(t) - K(t)) \qquad (19)$$

where B is an mxm matrix. For a single capital input the B matrix reduces to

$$B = -0.5\,(r - [r^2 - 4H''(K^*)/C''(0)]^{0.5}). \qquad (20)$$

This derivation allows the adjustment coefficient, B, to depend on economic forces: the discount rate, the cost of adjustment, the production relationship embodied in the profit function, and the profit maximizing behavior of the firm. If, however, the discount rate is constant and the adjustment cost function $C(\dot{K})$ is linear, then the adjustment coefficient is a constant and equation (19) reduces to the classical fixed accelerator model.

The rate of adjustment of the ith capital good generally depends on the difference between the desired and actual stock for all capital goods. Therefore, the simplest form of the accelerator, equation (19), does not generalize easily. Lucas shows, however, that a sufficient condition for B to be a diagonal matrix is that the stock of the ith capital good demanded is independent of the prices and stocks of other capital goods (*26*). This is a strong assumption, but a necessary one if this theoretical framework is to be extended to multiple capital inputs while maintaining a structure that can be estimated as a closed functional form.

Before the theoretical framework can be estimated, the adjustment equation must be expressed as a difference equation, and functional forms for the profit and cost of adjustment functions must be selected. The accelerator equation is respecified in a discrete form by first assuming that shortrun production is conditional on capital stocks at the beginning of the period. Therefore, capital stock adjustments during the period do not affect production until the following period. Second, the adjustment relationship specified in equation (19) is replaced by

$$K(t) - K(t-1) = B(K^*(t) - K(t-1)). \qquad (21)$$

A quadratic approximation is used for the profit function because it facilitates estimating the model without placing prior restrictions on the elasticities of substitution (*12*). The quadratic structure generates linear input demand functions and simple expressions for demand and substitution elasticities. In addition, the optimal paths for capital are globally rather than locally valid because the underlying differential equations are linear (*36*).

The UOP profit function is specified as a quadratic function of normalized input prices and the level of capital at the beginning of the current period.

$$\pi = b + b_t t + \sum_{i=1}^{n} b_{ti}tW_i + \sum_{i=1}^{m} b_{ki}tK_i + \sum_{i=1}^{m} a_iK_i + 0.5(\sum_{i=1}^{n} b_{ii}W_i^2 + a_{ii}\sum_{i=1}^{m} K_i^2) + 0.5\sum_{i=1}^{n}\sum_{i=1}^{n} b_{ij}W_iW_j + \sum_{i=1}^{n}\sum_{j=1}^{m} c_iW_iK_j \qquad (22)$$

where a's, b's, and c's are parameters and t is technological change.

If adjustment costs are external to the shortrun profit maximization decision, then necessary conditions for optimal capital adjustment are derived by applying equation (17). The steady-state solution is obtained by setting $\dot{K}_i = \ddot{K}_i = 0$.

$$K_i^* = -(a_i + b_{ki}t + \sum_{i=1}^{n} c_{ij}W_i - u_i)/a_{ii} \qquad (23)$$

$$i = 1,2,\ldots,m$$

where $u_i = q_i(r + \delta_i)$ is the normalized rental rate associated with the ith quasi-fixed factor.

The nonlinear adjustment relationship of equation (20) is simplified by assuming $C(\dot{K})$ is linear and the discount rate is constant. The difference equation reduces to a fixed accelerator model. There are several motivations for these simplifying assumptions. First, preliminary parameter estimates based on the more complicated nonlinear model lead to dubious parameter values and poor predictive ability.[9] The adjustment coefficient for some of the equations are less than zero. For equations with a logically consistent adjustment process there was little variation in the size of the adjustment rate suggesting that a fixed rate assumption is likely to have little effect on the structure of the estimated equations. Finally, the nonlinear model structure makes it generally difficult to achieve convergence when estimating the model.[10]

The estimated model is obtained by substituting the steady-state solution for capital and the implicit rental rate of capital into the difference equation (21) and appending a stochastic error having classical properties

$$K_i(t) - K_i(t-1) = B_i[-(a_i + b_{ki}t + \sum_{i=1}^{n} c_{ij}W_i - u_i^*)/a_{ii} - K_i(t-1)] + e_t \qquad (24)$$

$$i = 1,2,\ldots,m$$

where u_i^* is the normalized implicit rental rate of capital defined in equation (10). Equation (24) is estimated in its simpler linear form by multiplying through by $-B_i$ and dividing by a_{ii}

$$K_i(t) - K_i(t-1) = a_i^* + b_{ki}^*t + \sum_{i=1}^{n} c_{ij}^*W_i + B_i^*u_i^* - B_iK_i(t-1) + e_t \qquad (25)$$

$$i = 1,2,\ldots,m$$

where $a_i^* = -B_ia_i/a_{ii}$, $b_{ki}^* = -B_ib_{ki}/a_{ii}$, $c_{ij}^* = -B_ic_{ij}/a_{ii}$, and $B_i^* = -B_i/a_{ii}$. The original parameters in equation (24) are recoverable because each is identified in equation (25).

Data

The analysis uses aggregate time series data for 1955 through 1978. Except for the implicit rental rates, a detailed description of the data is available in Ball (*3*). The data were aggregated using a discrete Tornquist approximation of a Divisia index. Tornquist price indices are computed first, and then implicit quantity indices are computed by dividing value (revenue or expenditures) by the Tornquist price index.

Labor data were formulated to account for differences in the productivity of different types of workers and changes in quality due to education. Fertilizer data use information on primary nutrient content to account for quality changes. For capital, the separation of price and quantity components of outlays is based on the correspondence between the value of an asset and the discounted value of its services (*14*). The implicit rental rate or service price depends on the asset price, rate of economic depreciation, service life, tax treatment, and the discount rate. Asset prices, the rate of economic depreciation, and service lives are taken from Ball (*3*). The tax parameters such as the depreciation method, tax life, and investment tax credit are based on eligibility requirements at the time the asset was purchased. If more than one option was allowable, the method resulting in the lowest rental rate was selected. The marginal ex ante Federal income tax rates developed for this analysis are interpreted as the expected tax rate an investor or firm would pay on an additional dollar of income prior to undertaking any new investment. These ex ante rates are estimated for sole proprietorships from U.S. Department of the Treasury data for 1962-78 (table 1).

Prior to the Revenue Act of 1964, the lowest marginal tax rate applied to all taxable income below $2,000. It was assumed that the appropriate marginal tax rate corresponded to the lowest tax bracket. Therefore, the ex ante marginal tax rate from 1955-61 was 20 percent.

[9]Poor predictive ability is consistent with the results of Watkins and Berndt (*44*) where the single-equation R^2 statistic associated with their investment equation was 0.058.

[10]Difficulties associated with estimating the nonlinear investment model suggest Feldstein's (*11*) observation that specifications derived from a rich economic theory often overexhaust the information in the data.

The discount rate is assumed to be a weighted average of the longrun real interest rate (external financing) and the longrun real return to equity (internal financing). Weights were computed from Bureau of Census data (*40, 41*). Interest rates are those charged by Federal land banks on new farm loans. The longrun rate of return to equity is based on Gertel and Melichar (*13, 27*).

Estimated Model

A maximum likelihood system estimator was used to capture interequation covariance among the four investment equations. The structure of the equations is given by equation (25). The values of the estimated parameters and their associated asymptotic standard errors are reported in table 2. Predictions from the estimated model closely parallel observed investment behavior for each asset (figs. 1-4). Single equation R^2's and Durbin-Watson statistics are, respectively: long-lived equipment, 0.74 and 1.91; short-lived equipment, 0.78 and 1.66; structures, 0.52 and 2.18; and land, 0.65 and 1.96.

The estimated parameters generate a plausible model structure. The parameters associated with the rental rate for each asset have the expected sign. The adjustment rates are reasonable because they are dynamically stable. The highest rate, 0.78, is associated with land, and the lowest, 0.17, is associated with structures. Increases in normalized variable input prices generally decrease investment for each asset (12 out of 16 parameters). Only energy price increases tend to increase investment.

Optimal levels for each asset class are computed using equation (23). Except for land, the optimal capital stock exceeds the predicted capital stock for nearly every observation (table 3). Predicted stocks of short-lived equipment (1956-61) exceed the optimal levels, but in these cases the difference is less than 5 percent. The predicted stock of land exceeds the optimal level in all years except 1959 and 1973. However, the predicted stock of land never exceeds the optimal level by more

Table 1—Estimated marginal income tax rates, per farm, 1955-78

Year	Adjusted gross income	Taxable income	Marginal income tax rates
	Dollars		*Percent*
1962	4,853.33	1,968.00	20
1963	5,033.17	2,129.85	20
1964	5,907.53	2,916.78	20
1965	6,718.01	3,646.21	17
1966	7,028.83	3,935.39	17
1967	7,381.25	4,243.12	19
1968	8,128.65	4,915.78	19
1969	8,633.66	5,370.29	19
1970	8,869.38	5,482.44	19
1971	9,507.02	5,571.11	19
1972	11,404.88	6,694.15	19
1973	13,765.56	8,765.56	22
1974	14,311.56	9,311.56	22
1975	14,626.73	9,626.73	22
1976	15,814.81	10,442.59	22
1977	14,661.82	11,661.82	22
1978	19,133.01	16,133.01	25

Table 2—Estimated parameters

Item	Coefficient	Value	Asymptotic standard error
Short-lived equipment	a_s^*	1,978.140	1,060.900
	B_s	.276	.062
	B_s^*	−14,737.900	4,487.060
	b_{ks}^*	92.410	25.360
	c_{as}^*	1,807.200	1,216.100
	c_{cs}^*	447.000	768.600
	c_{es}^*	1,317.880	1,175.500
	c_{fs}^*	784.350	1,044.200
Long-lived equipment	a_l^*	5,187.060	1,418.600
	B_l	.179	.057
	B_l^*	−31,168.300	10,022.200
	b_{kl}^*	211.090	58.300
	c_{al}^*	4,562.330	1,403.200
	c_{cl}^*	2,108.940	1,177.500
	c_{el}^*	−5,022.900	1,483.500
	c_{fl}^*	628.300	1,725.200
Structures	a_b^*	5,223.480	3,137.500
	B_b	.168	.154
	B_b^*	−16,718.500	5,951.180
	b_{kb}^*	110.420	117.300
	c_{ab}^*	1,019.490	1,187.660
	c_{cb}^*	−822.400	699.500
	c_{eb}^*	1,556.630	1,019.950
	c_{fb}^*	−206.790	798.600
Land	a_t^*	348,612.000	18,877.900
	B_t	.775	.070
	B_t^*	−271,299.000	20,894.400
	b_{kt}^*	−2,733.740	625.600
	c_{at}^*	81,387.900	16,530.000
	c_{ct}^*	32,563.900	7,459.000
	c_{et}^*	−84,935.100	5,964.000
	c_{ft}^*	38,347.500	3,435.600

Note: Coefficient symbols are defined as follows: s is short-lived equipment, l is long-lived equipment, b is structures, t is land, a is labor, c is chemicals, e is energy, and f is feed-seed. All other symbols are defined in equation (25).

Figure 1

Net Investment in Short-Lived Equipment, 1956-78

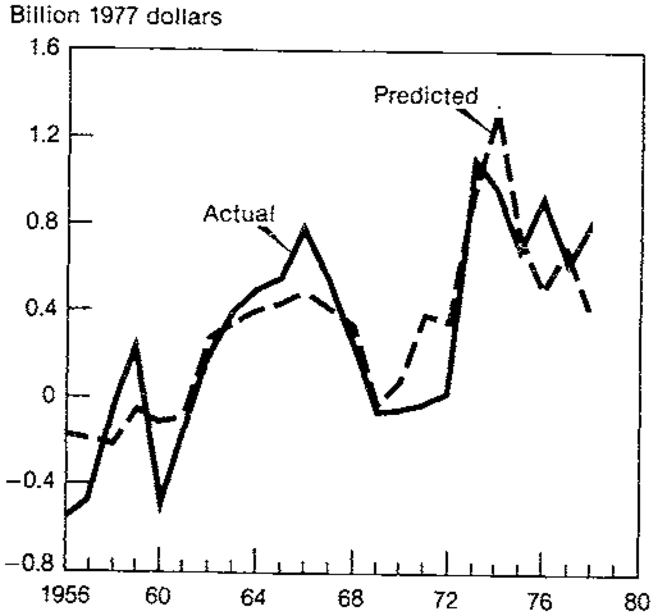

Figure 2

Net Investment in Long-Lived Equipment, 1956-78

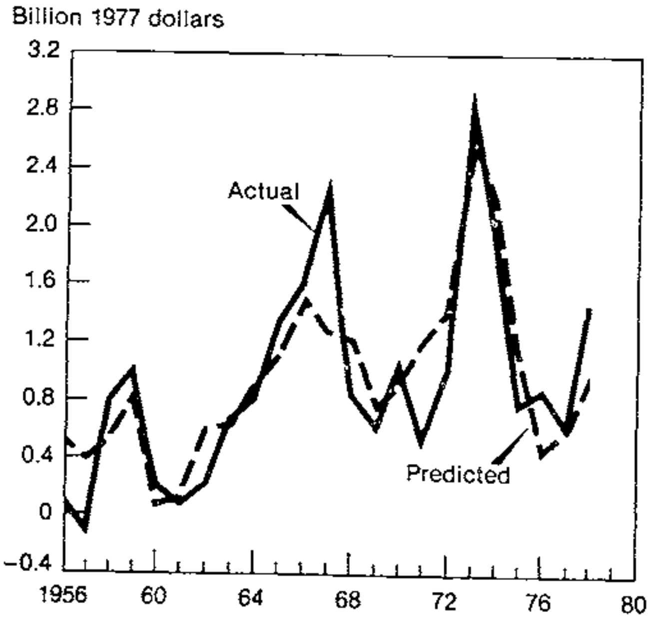

Figure 3

Net Investment in Structures, 1956-78

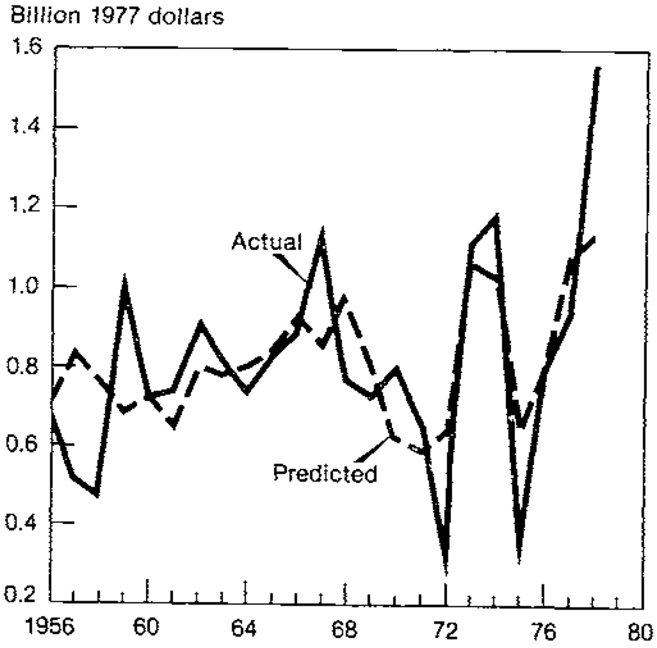

Figure 4

Net Investment in Land, 1956-78

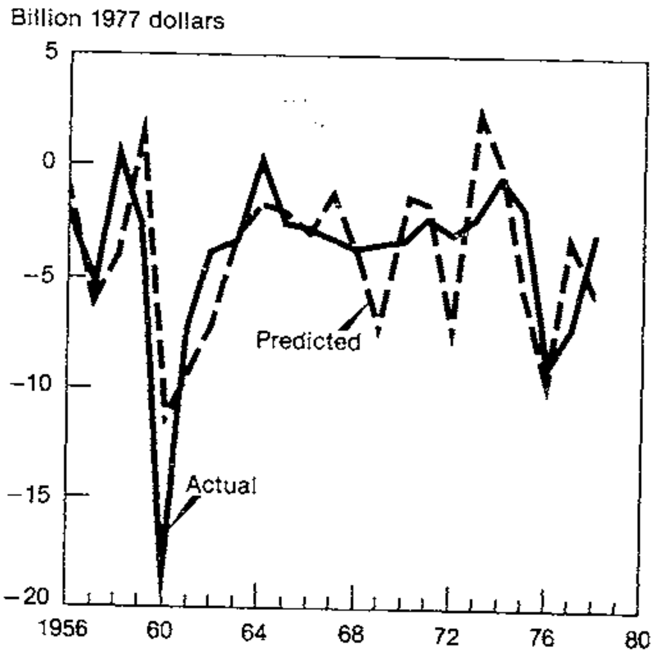

Table 3—Predicted and optimal capital stock, 1956-78

Year	Short-lived equipment		Long-lived equipment		Structures		Land	
	K	K*	K	K*	K	K*	K	K*
	Million 1977 dollars							
1956	12,144	11,648	31,078	33,387	28,831	32,267	498,526	498,294
1957	11,949	11,436	31,452	33,162	29,633	33,621	492,654	490,946
1958	11,737	11,181	31,984	34,420	30,383	34,105	488,626	487,454
1959	11,667	11,483	32,803	36,557	31,059	34,414	490,370	490,877
1960	11,547	11,233	32,916	33,433	31,779	35,357	478,752	475,372
1961	11,474	11,281	33,075	33,801	32,452	35,796	469,604	466,943
1962	11,726	12,387	33,653	36,302	33,252	37,224	462,687	460,675
1963	12,042	12,874	34,246	36,959	34,028	37,880	459,885	459,071
1964	12,414	13,390	35,068	38,832	34,813	38,712	458,343	457,894
1965	12,836	13,943	36,145	41,076	35,637	39,729	456,399	455,833
1966	13,334	14,643	37,570	44,093	36,546	41,062	453,588	452,771
1967	13,755	14,859	38,827	44,583	37,386	41,559	452,555	452,255
1968	14,090	14,971	40,056	45,684	38,335	43,046	448,758	447,653
1969	14,129	14,229	40,894	44,730	39,173	43,334	441,922	439,933
1970	14,216	14,445	41,850	46,229	39,837	43,137	440,780	440,448
1971	14,554	15,441	43,035	48,459	40,453	43,514	439,115	438,631
1972	14,929	15,916	44,505	51,237	44,117	44,412	432,099	430,058
1973	15,888	18,405	47,058	58,748	42,127	47,143	435,002	435,846
1974	17,163	20,512	49,193	58,965	43,142	48,182	434,990	434,986
1975	17,945	19,998	50,402	55,939	43,842	47,321	429,244	427,572
1976	18,469	19,845	50,948	53,447	44,651	48,667	419,339	416,458
1977	19,071	20,653	51,535	54,224	45,692	50,865	416,295	415,410
1978	19,534	20,750	52,498	56,908	46,825	52,452	410,727	409,108

Note: K and K* are defined in equations (11) and (18), respectively.
K = predicted capital stock.
K* = optimal capital stock.

than 1 percent. The optimal capital stock for all assets except land increase from 1956 to 1978: short-lived equipment (78 percent), long-lived equipment (70 percent), structures (63 percent), and land (−18 percent). The growth in stocks of equipment and structures increase at a decreasing rate since the early seventies.[11]

Tax Policy Effects

The effects of the investment tax credit, interest deductibility, and the complete set of tax changes instituted since 1954 on net investment and optimal capital stock are assessed for each of the four asset classes.[12] The effects of these tax policies are manifested through changes in the rental rates. The magnitude of the effects is determined by comparing net investment and optimal capital stock under the tax regime prevailing during 1955-78 to three alternative simulations assuming: (1) no investment tax credits, (2) no interest deductibility, and (3) all provisions revert to a pre-1954 tax environment.

Investment Tax Credit

The importance of the tax credit relative to other tax policy changes is that it represents a dollar-for-dollar reduction in tax liability. A tax credit of 7 percent for qualifying plant and equipment investments was first instituted in 1962 and then repealed in 1969.[13] The tax credit was, however, restored in 1971 and increased to 10 percent in 1975. The results from this analysis suggest the investment tax credits of 1962 and 1971 had significant effects on both short- and long-lived equipment investment and, to a lesser extent, on structures

[11] This result parallels declines in the rate of measured productivity growth in agriculture beginning in the midseventies.

[12] The effects of accelerated depreciation on net investment are also examined. The results indicate virtually no effect and are, therefore, not reported.

[13] In this analysis both short- and long-lived equipment qualify for the investment tax credit. Only crop storage structures beginning in 1962 and unitary livestock structures beginning in 1971 are eligible for the credit. Land does not qualify for the investment tax credit.

(table 4). For example, in 1962 the investment tax credit accounts for nearly 63 percent of net investment in total agricultural equipment ($526 million) and 5 percent for structures ($41 million). These figures do not represent the full impact of the credit because capital stock adjusts gradually. By 1969, when the credit was repealed, the tax credit engendered nearly $900 million more net investment in short-lived equipment, $1.3 billion in long-lived equipment, and $200 million in structures. Over the entire period 1962-78, over $3 billion in net equipment investment ($1.2 billion in short-lived equipment and $1.8 billion in long-lived equipment), representing 12 percent of total net investment in equipment, and $500 million or 5 percent in structures is attributed to the investment tax credit.

This increase in net investment resulting from the tax credit represents about 5.8 percent of the optimal stock of short-lived equipment and 3.2 percent of the optimal stock of long-lived equipment in 1978. The relatively greater impact on short-lived equipment compared with long-lived equipment represents a bias toward short-lived assets. Short-lived assets are purchased more frequently and, therefore, receive a greater amount of benefit from the credit.

The effects of the tax credit on short-lived and long-lived equipment and structures have the same pattern. The largest effects occur in 1962 and 1971. The smallest effects occur in 1973 and 1974 when high rates of inflation and high output prices diminish the differences between the rental rates with and without the investment tax credits. Also, net investment for both classes of equipment and structures is greater for the "without-credit" simulations in 1969 and 1970 and again in 1973 and 1974. This seemingly anomalous result occurs when there is no difference or only a small difference between the rental rates for simulations with and without the credit. The "anomalous" result is explained by the effect of lagged adjustment on net investment in period t.

The effects of tax policy enter the investment functions through the rental rate and the optimal level of capital stock. Because the optimal capital stock is the steady-state solution to the dynamic optimization problem, tax

Table 4—Net investment under alternative tax policies, 1956-78

Year	Short-lived equipment				Long-lived equipment				Structures				Land			
	$\dot{K}$	$\dot{K}_{itc}$	$\dot{K}_{int}$	$\dot{K}_{pre}$	$\dot{K}$	$\dot{K}_{itc}$	$\dot{K}_{int}$	$\dot{K}_{pre}$	$\dot{K}$	$\dot{K}_{itc}$	$\dot{K}_{int}$	$\dot{K}_{pre}$	$\dot{K}$	$\dot{K}_{itc}$	$\dot{K}_{int}$	$\dot{K}_{pre}$
	Million 1977 dollars															
1956	−190	−190	−237	−245	504	504	419	391	692	692	636	656	−798	−798	−857	−798
1957	−195	−195	−244	−242	374	374	272	267	803	803	745	776	−5,872	−5,872	−6,054	−5,872
1958	−212	−212	−249	−265	532	532	447	400	749	749	702	715	−4,028	−4,028	−4,156	−4,028
1959	−70	−70	−100	−107	820	820	739	707	676	676	633	646	1,744	1,744	1,615	1,744
1960	−120	−120	−152	−158	113	113	27	5	720	720	675	692	−11,619	−11,619	−11,852	−11,619
1961	−74	−74	−92	−92	159	159	94	77	673	673	640	651	−9,148	−9,148	−9,222	−9,148
1962	252	6	242	−14	578	298	541	180	800	759	781	684	−6,917	−6,917	−6,860	−6,917
1963	317	137	309	119	593	360	561	250	776	742	756	677	−2,801	−2,801	−2,848	−2,801
1964	372	183	367	170	822	558	796	467	785	746	768	689	−1,542	−1,542	−1,660	−1,542
1965	422	308	436	316	1,077	884	1,07[illegible]	855	824	795	825	771	−1,945	−1,945	−1,777	−1,945
1966	499	444	511	449	1,425	1,301	1,431	1,286	909	890	913	877	−2,810	−2,810	−2,737	−2,810
1967	420	354	413	340	1,257	1,122	1,230	1,056	840	818	824	783	−1,033	−1,033	−1,346	−1,033
1968	336	293	323	269	1,229	1,123	1,193	1,057	949	931	922	902	−3,798	−3,798	−4,090	−3,798
1969	38	265	14	245	838	1,077	782	1,019	838	872	796	846	−6,836	−6,836	−7,085	−6,836
1970	87	251	56	232	956	1,153	877	1,090	664	693	608	679	−1,142	−1,142	−1,491	−1,142
1971	338	172	323	130	1,185	987	1,143	903	616	537	576	491	−1,665	−1,665	−1,670	−1,665
1972	376	291	384	287	1,470	1,353	1,470	1,325	664	609	651	585	−7,016	−7,016	−6,742	−7,016
1973	959	991	979	984	2,553	2,567	2,583	2,583	1,010	997	1,012	1,008	2,902	2,902	3,281	2,902
1974	1,275	1,299	1,283	1,278	2,134	2,149	2,144	2,150	1,015	1,005	1,002	1,016	−12	−12	157	−12
1975	782	646	761	605	1,209	997	1,153	901	700	633	659	609	−5,746	−5,746	−6,751	−5,746
1976	524	390	499	357	546	310	477	199	809	745	772	711	−9,905	−9,905	−10,483	−9,905
1977	603	483	580	435	587	378	521	255	1,042	987	1,005	956	−3,044	−3,044	−3,430	−3,044
1978	463	402	436	336	963	827	889	683	1,133	1,097	1,085	1,066	−5,568	−5,568	−6,026	−5,568

Note: The following symbols are used above:
$\dot{K}$ is net investment under 1955-78 tax provisions, $\dot{K}_{itc}$ is net investment without the tax credit, $\dot{K}_{int}$ is net investment without interest deduction, and $\dot{K}_{pre}$ is net investment under pre-1954 tax provisions.

effects on the optimal capital stock represent the fully adjusted or longrun impact on capital stock. In the presence of the investment tax credit in 1962, the optimal capital stock for equipment is $48.7 billion and $37.2 billion for structures (table 5). Without the tax credit, the optimal capital stocks decrease to $46.2 billion and $37 billion, respectively. By 1978, the optimal capital stock is 5.3 percent higher for total equipment (7 percent higher for short-lived equipment and 4.8 percent higher for long-lived equipment), and 1.3 percent higher for structures.

Interest Deductibility

The deductibility of interest payments from income was allowed throughout 1955-78 for all of the asset classes. Unlike the investment tax credit, the deductibility of interest payments is not a dollar-for-dollar reduction in taxes, but instead is affected by the firm's tax rate. The presence of the interest deduction has a significant effect on all assets resulting in net investment increases of $360 million for short-lived equipment, $1 billion for long-lived equipment, $701 million for structures, and $3.5 billion for land.

Although these increases in net investment are less than those caused by the investment tax credit, the interest deduction supplements the credit for much of the period studied. Because the investment tax credit had such a significant impact on rental rates, the importance of the interest rate as a determinant of net investment was overshadowed. Prior to the enactment of the credit in 1962, the interest deduction averted a $213-million drop in net investment in short-lived equipment and an $805-million drop in land. In addition, from 1956-61, the interest deduction increased net investment by $504 million for long-lived equipment and $282 million for structures. Again, in 1969-70, when the investment tax credit was repealed, the deductibility of interest charges became an increasingly important determinant of net investment. The interest deduction increased net investment by $55 billion for short-lived equipment, $137 billion for long-lived equipment, and $98 billion for structures over this 2-year period.

Table 5—Optimal capital stock under alternative tax policies, 1956-78

Year	Short-lived equipment				Long-lived equipment				Structures				Land			
	K^*	K^*_{itc}	K^*_{int}	K^*_{pre}	K^*	K^*_{itc}	K^*_{int}	K^*_{pre}	K^*	K^*_{itc}	K^*_{int}	K^*_{pre}	K^*	K^*_{itc}	K^*_{int}	K^*_{pre}
	Million 1977 dollars															
1956	11,648	11,648	11,414	11,383	33,387	33,387	32,811	32,630	32,267	32,267	31,868	32,012	498,294	498,294	497,714	498,294
1957	11,436	11,436	11,152	11,151	33,162	33,162	32,405	32,333	33,621	33,621	33,153	33,380	490,946	490,946	490,148	490,946
1958	11,181	11,181	10,891	10,824	34,420	34,420	33,656	33,343	34,105	34,105	33,640	33,793	487,454	487,454	486,545	487,454
1959	11,483	11,483	11,181	11,131	36,557	36,556	35,731	35,456	34,414	34,414	33,934	34.099	490,877	490,877	489,838	490,877
1960	11,233	11,233	10,892	10,842	33,433	33,433	32,498	32,247	35,357	35,357	34,814	35,020	475,372	475,372	474,070	475,372
1961	11,281	11,281	10,959	10,923	33,801	33,801	32,897	32,654	35,796	35,796	35,284	35,463	466,943	466,943	465,613	466,943
1962	12,387	11,482	12,078	11,113	36,302	34,735	35,485	33,305	37,224	36,983	36,762	36,313	460,675	460,675	459,440	460.675
1963	12,874	11,964	12,564	11,583	36,959	35,383	36,137	33,876	37,880	37,638	37,396	36,957	459,071	459,071	457,759	459,071
1964	13,390	12,267	13,082	11,884	38,832	36,844	38,009	35,335	38,712	38,404	38,221	37,703	457,894	457,894	456,445	457,894
1965	13,943	12,903	13,700	12,584	41,076	39,223	40,381	37,966	39,729	39,444	39,330	38,881	455,833	455,833	454,634	455,833
1966	14,643	13,702	14,409	13,384	44,093	42,435	43,430	41,229	41,062	40,802	40,681	40,283	452,771	452,771	451,617	452,771
1967	14,859	13,820	14,565	13,438	44,583	42,733	43,736	41,228	41,559	41,265	41,061	40,600	452,255	424,255	450,676	452,255
1968	14,971	13,953	14,652	13,519	45,684	43,864	44,759	42,290	43,046	42,757	42,474	42,096	447,653	447,653	445,789	447,653
1969	14,229	14,146	13,853	13,700	44,730	44,730	43,658	43,137	43,334	43,335	42,642	42,664	439,933	439,933	437,833	439,933
1970	14,445	14,360	14,020	13,899	46,229	46,229	44,970	44,550	43,137	43,137	42,313	42,511	440,448	440,448	437,968	440,448
1971	15,441	14,323	15,044	13,760	48,459	46,458	47,331	44,598	43,514	42,900	42,733	42,070	438,631	438,631	436,427	438,631
1972	15,916	14,928	15,588	14,461	51,237	49,486	50,301	47,854	44,412	43,866	43,756	43,123	430,058	430,058	428,029	430,058
1973	18,405	17,758	18,130	17,274	58,748	57,611	57,979	56,195	47,143	46,792	46,562	46,231	435,846	435,846	434,226	435,846
1974	20,512	19,865	20,212	19,323	58,965	57,848	58,115	56,364	48,182	47,838	47,516	47,286	434,986	434,986	433,475	434,986
1975	19,998	18,797	19,603	18,163	55,939	53,569	54,728	51,544	47,321	46,619	46,467	45,875	427,572	427,572	424,715	427,572
1976	19,845	18,512	19,414	17,868	53,447	50,735	52,108	48,531	48,667	47,924	47,804	47,091	416,458	416,458	413,146	416,458
1977	20,653	19,241	20,207	18,508	54,224	51,424	52,833	49,042	50,865	50,110	49,967	49,266	415,410	416,410	411,768	415,410
1978	20,750	19,429	20,265	18,585	56,908	54,305	55,404	51,684	52,452	51,755	51,450	50,875	409,108	409,108	404,987	409,108

Note: The following symbols are used above:
K^* is the optimal capital stock under 1955-78 tax provisions, K^*_{itc} is the optimal capital stock without the tax credit, K^*_{int} is the optimal capital stock without interest deduction, and K^*_{pre} is the optimal capital stock under pre-1954 tax provisions.

During the interim period from 1962-68 and again after 1970, relatively stable real interest rates, coupled with favorable tax treatment and relatively low inflation rates, reduced the impact of the interest deduction on investment. In 1964-65 and during the early seventies, net investment was greater without the interest deduction as the capital stock continued to adjust from impacts in previous periods. Not until the late seventies as high rates of inflation eroded the value of the investment tax credit did the interest deduction have a significant impact on net investment.

The optimal capital stock has also increased over the period studied as a result of the deductibility of interest expenses. In 1956, the optimal capital stock for the equipment categories and for the structure category without the interest deduction was less than 2 percent and for land was less than 0.2 percent smaller than the optimal capital stock with the interest deduction. By 1978, the optimal capital stock without the interest deduction was 2.4 percent smaller for short-lived equipment, 2.7 percent smaller for long-lived equipment, and 1.9 percent and 1 percent smaller for structures and land, respectively. The relatively greater impact of the interest deduction on the optimal capital stock of land emphasizes the importance of the interaction of the investment tax credit and the interest deduction on the optimal stocks of the other asset categories. In addition, unlike the investment tax credit, the interest deduction reduces the rental rate for longer lived assets relative to assets with shorter lives. As interest rates fall, investors are less concerned with committing resources over a longer period of time. Therefore, the demand for longer lived assets increases relative to the demand for shorter lived assets.

Pre-1954 Tax Laws

The pre-1954 scenario captures the impact of all the tax changes occurring since 1954. Under this scenario, tax lives are set equal to economic lives, the tax depreciation method is limited to the straight line method, and no additional first year depreciation or investment tax credit is assumed. Interest expenses, however, are deductible from income for tax purposes. For short-lived and long-lived equipment, net investment and the optimal stock are almost identical to the scenario in which the investment tax credit was not enacted. This reinforces the result that of all the tax changes, the investment tax credit has the greatest impact on molding the structure of the capital stock. However, this does not mean that other tax changes have no impact. Total net investment under the pre-1954 scenario is $625 million less for short-lived equipment, $1.8 billion less for long-lived equipment, and $683 million less for structures without the shorter tax lives, accelerated depreciation methods, and additional first year depreciation option.[14]

The effect of all the tax changes since 1954 have the greatest impact on the optimal capital stock of short-lived equipment. In 1956 the optimal stock of short-lived equipment was 2.3 percent less under the pre-1954 scenario. In 1978, the optimal stock of short-lived equipment was 11.6 percent less under the pre-1954 scenario. From 1956 to 1978 the difference between the optimal level of long-lived equipment and structures and the optimal level under the pre-1954 scenario increased from 2.3 percent to 10.1 percent and from 0.8 percent to 3.1 percent, respectively.

Conclusions

The effects of tax policy on net investment in short-lived and long-lived agricultural equipment, farm structures, and land are examined. The study included three tax alternatives: the investment tax credit, interest deductibility, and the interaction of all new tax provisions promulgated since 1954. The results generally support the Hall and Jorgenson thesis that tax policy is effective in changing the level of investment (*16*). Nearly 20 percent of net investment in agricultural equipment during the period of 1956-78 is attributed to tax policy. The results also suggest that the investment tax credit was probably the most effective tool in stimulating investment.

The results in this analysis are subject to the static price expectation assumptions implicit in the dynamic optimization of profit as well as the simplified accelerator structure used to estimate the investment system. Furthermore, it is assumed that changes in tax policy are instantaneous and perceived to be permanent. There are good reasons to expect information on new tax measures to diffuse throughout the economy. In addition, tax credits may be temporary and depreciation allowances may increase.

Nevertheless, the weight of this analysis suggests that a significant share of investment in agricultural assets can be attributed to tax policy. To the extent that investment leads to output expansion and induces productivity growth, tax policy and farm commodity programs are contradictory. This contradiction does not

[14] Land was never eligible for the investment tax credit, additional first-year depreciation deduction, or accelerated depreciation methods.

suggest that tax policy is not necessary to achieve tax neutrality or that it may not help alleviate cash flow problems and buoy income, the ultimate objective of farm policy. Attempts to restrict agricultural output are, however, partially offset by investment stimulated by changes in tax policy.

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