TAX POLICY AND INVESTMENT BEHAVIOR

By ROBERT E. HALL AND DALE W. JORGENSON*

The effectiveness of tax policy in altering investment behavior is an article of faith among both policy makers and economists. Whatever the grounds for this belief, its influence on postwar tax policy in the United States has been enormous. In 1954 and again in 1962 amortization of capital expenditures was liberalized by providing for faster writeoffs. Since 1962 a tax credit for expenditure on equipment has been in force. Nor is tax policy in the United States atypical. As Otto Eckstein [8] has pointed out,

> Tax devices to stimulate investment have certainly been the greatest fad in economic policy in the past ten years. In a period when the trends in the use of policy instruments were in the direction of more general, less selective devices, all sorts of liberalized depreciation schemes, investment allowances, and tax exemptions were embraced with enthusiasm all over the non-Communist world.[1]

The customary justification for the belief in the efficacy of tax stimulus does not rely on empirical evidence. Rather, the belief is based on the plausible argument that businessmen in pursuit of gain will find the purchase of capital goods more attractive if they cost less.[2] In view of the policy implications of this theoretical argument, it is surprising that no attempt has been made to estimate the magnitude of tax effects on investment. Previous studies have been limited to calculations of the effects of tax policy on the cost of capital services.[3] The relation between these changes in the cost of capital and actual investment expenditures has not been studied empirically. As a result, the most important questions for economic policy—How much investment will result from a given policy measure? When will it occur?—have been left unanswered.

The purpose of this paper is to study the relationship between tax policy and investment expenditures using the neoclassical theory of

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[1] See [8, p. 351]; an excellent comparison of U.S. and European tax policy, including depreciation policy and investment tax credits, is given in [7].

[2] The effects of tax policy on investment behavior are analyzed from this point of view by N. B. Ture [19, esp. pp. 341–45]; by S. B. Chase, Jr. [3]; and by R. A. Musgrave [15, pp. 53–54, 117–29]. Many other references could be given.

[3] See, for example: E. C. Brown [2] and Chase [3, pp. 46–52].

optimal capital accumulation.[4] First, we measure the cost to the business firm of employing fixed assets. This cost depends on the rate of return, the price of investment goods, and the tax treatment of business income. Second, we determine empirically the relation between the cost of employing capital equipment and the level of investment expenditures. This relationship is a straightforward generalization of the familiar flexible accelerator theory of investment. We first obtain an estimate of the distribution over time of the investment expenditures resulting from a given increment in the desired level of capital services; then we estimate both the amount of investment resulting from a change in tax policy and its distribution over time. We consider the effects of: (1) the adoption of accelerated methods for computing depreciation for tax purposes in 1954, (2) the investment tax credit of 1962, and (3) the depreciation guidelines of 1962. As an illustration we consider the hypothetical effects of (4) adoption of first-year writeoff in 1954 in place of less drastic accelerated depreciation.

Our basic conclusion is that tax policy is highly effective in changing the level and timing of investment expenditures. In addition we find that tax policy has had important effects on the composition of investment. According to our estimates, the liberalization of depreciation rules in 1954 resulted in a substantial shift from equipment to structures. On the other hand, the investment tax credit and depreciation guidelines of 1962 caused a shift toward equipment.

I. *Tax Policy and the Cost of Capital Services*

The neoclassical theory of optimal capital accumulation may be formulated in two alternative and equivalent ways. First, the firm may be treated as accumulating assets in order to supply capital services to itself. The objective of the firm is to maximize its value, subject to its technology. Alternatively, the firm may be treated as renting assets in order to obtain capital services; the firm may rent assets from itself or from another firm. In this case, the objective of the firm is to maximize its current profit, defined as gross revenue less the cost of current inputs and less the rental value of capital inputs. The rental can be calculated from the basic relationship between the price of a new capital good and the discounted value of all the future services derived from this capital good.[5] In the absence of direct taxation this relationship takes the form:

$$q(t) = \int_t^\infty e^{-r(s-t)}c(s)e^{-\delta(s-t)}ds, \tag{1}$$

where r is the discount rate, q the price of capital goods, c the cost of

[4] This model has been studied previously by D. W. Jorgenson [11 and 12].

[5] The equivalence of these two formulations is discussed by D. W. Jorgenson [14].

capital services, and δ the rate of replacement; in this formulation t is the time of acquisition of the capital goods and s the time at which capital services are supplied. Differentiating this relationship with respect to time of acquisition we obtain:

$$c = q(r + \delta) - \dot{q}, \tag{2}$$

which is the rental of capital services supplied by the firm to itself. Under static expectations about the price of investment goods, the rental reduces to:

$$c = q(r + \delta). \tag{3}$$

Expression (3) derived above for the cost of capital services may be extended to take account of a proportional tax on business income. We assume that the tax authorities prescribe a depreciation formula $D(s)$ which gives the proportion of the original cost of an asset of age s that may be deducted from income for tax purposes. Further, we assume that a tax credit at rate k is allowed on investment expenditure and that the depreciation base is reduced by the amount of tax credit.[6] If the tax rate is constant over time at rate u, the equality between the price of investment goods and the discounted value of capital services is:

$$q(t) = \int_t^\infty e^{-r(s-t)}[(1 - u)c(s)e^{-\delta(s-t)} + u(1 - k)q(t)D(s)]ds + kq(t). \tag{4}$$

Denoting by z the present value of the depreciation deduction on one dollar's investment (after the tax credit),

$$z = \int_0^\infty e^{-rs}D(s)ds. \tag{5}$$

The implicit rental value of capital services under static expectations then becomes:

$$c = q(r + \delta)\,\frac{(1 - k)(1 - uz)}{1 - u} \tag{6}$$

Under the Internal Revenue Code of 1954 at least three depreciation formulas could be employed for tax purposes: straight-line, sum of the years' digits, and double declining balance. To obtain the appropriate cost of capital services for each formula, it is necessary to calculate the present value of the depreciation deduction for each one. Throughout we assume that the asset has no salvage value.

For straight-line depreciation, the deduction is constant over a period of length τ, the lifetime for tax purposes:

[6] This assumption is valid for 1962 and 1963. For 1964 and later years the depreciation base was not reduced by the amount of the tax credit.

$$D(s) = \begin{cases} \dfrac{1}{\tau} & \text{for } 0 \leqq s \leqq \tau, \\ 0 & \text{otherwise.} \end{cases}$$

The present value of the deduction is:

$$\begin{aligned} z &= \int_0^\tau \frac{e^{-rs}}{\tau}\, ds, \\ &= \frac{1}{r\tau}\,(1 - e^{-r\tau}). \end{aligned} \tag{7}$$

For sum of the years' digits, the deduction declines linearly over the lifetime for tax purposes:

$$D(s) = \begin{cases} \dfrac{2(\tau - s)}{\tau^2} & \text{for } 0 \leqq s \leqq \tau, \\ 0 & \text{otherwise.} \end{cases}$$

The present value of the deduction is:

$$\begin{aligned} z &= \int_0^\tau e^{-rs}\,\frac{2(\tau - s)}{\tau^2}\, ds, \\ &= \frac{2}{r\tau}\left[1 - \frac{1}{r\tau}\,(1 - e^{-r\tau})\right]. \end{aligned} \tag{8}$$

Tax provisions for double declining balance depreciation are more complicated. A firm may switch to straight-line depreciation at any time. If the switchover point is denoted τ^+, the double declining balance depreciation formula is:

$$D(s) = \begin{cases} \dfrac{2}{\tau}\, e^{-(2/\tau)s} & \text{for } 0 \leqq s \leqq \tau^+, \\ \dfrac{1 - e^{-(2/\tau)\tau^+}}{\tau - \tau^+} & \text{for } \tau^+ \leqq s \leqq \tau \\ 0 & \text{otherwise.} \end{cases}$$

The present value of the deduction is:

$$\begin{aligned} z &= \frac{2}{\tau}\int_0^{\tau^+} e^{-(r+(2/\tau))s} ds + \frac{1 - e^{-(2/\tau)\tau^+}}{\tau - \tau^+}\int_{\tau^+}^{\tau} e^{-rs} ds, \\ &= \frac{\dfrac{2}{\tau}}{r + \dfrac{2}{\tau}}\,[1 - e^{-(r+(2/\tau))\tau^+}] + \frac{1 - e^{-(2/\tau)\tau^+}}{r(\tau - \tau^+)}\,(e^{-r\tau^+} - e^{-r\tau}). \end{aligned} \tag{9}$$

The switchover point which maximizes z is $\tau^+ = \tau/2$.

Representative values of the present value of the deduction for each of the three methods are given in Table 1.[7] From this table it is clear that the sum of the years' digits depreciation formula dominates the double declining balance and straight-line formulas in the range of discount rates and lifetimes with which we are concerned. For this reason we have represented the 1954 tax revision as a change from straight-line to sum of the years' digits depreciation formulas.[8] Under static expectations the formulas for the rental value of capital services for these two methods of depreciation are:

TABLE 1—PRESENT VALUE OF DEPRECIATION DEDUCTION

Lifetime	Interest Rate	Straight-line	Sum of the Years' Digits	Double Declining Balance
5	.06	.864	.907	.888
5	.12	.752	.827	.795
10	.06	.752	.827	.795
10	.12	.582	.696	.651
25	.06	.518	.643	.594
25	.12	.317	.456	.410
40	.06	.379	.518	.469
40	.12	.207	.331	.297

straight-line:

$$c = \frac{1-k}{1-u} q(r+\delta)\left[1 - \frac{u}{r\tau}(1 - e^{-r\tau})\right]; \tag{10}$$

sum of the years' digits:

$$c = \frac{1-k}{1-u} q(r+\delta)\left[1 - u\frac{2}{r\tau}\left(1 - \frac{1}{r\tau}\{1 - e^{-r\tau}\}\right)\right]. \tag{11}$$

Under the assumption that firms behave so as to maximize profit and that the markets for their output are perfectly competitive, a firm's

[7] The results presented in Table I may be compared with those of Sidney Davidson and D. F. Drake [5]; see also: Davidson and Drake [6].

[8] The adoption of accelerated methods for computing depreciation in 1954 involved a change from straight-line depreciation to either sum of the years' digits or double declining balance formulas. Since sum of the years' digits offers a slight advantage over double declining balance, we have assumed that accelerated depreciation was taken in the form of the sum of the years' digits. Further, we have assumed that accelerated methods were adopted immediately after they were made available. In fact, approximately 50 per cent (of new assets) were depreciated on an accelerated basis the first year and a similar percentage of the uncovered balance was added in subsequent years. For firms that had negotiated shorter lifetimes than those allowed beginning 1954, there was some incentive to continue using straight-line methods in order to meet the "reserve ratio test," now effectively abandoned. The shorter lifetimes may be approximated by accelerated depreciation.

desired level of capital can be derived from the condition that the value of the marginal product of capital should be equal to the rental price of capital. For a Cobb-Douglas production function, the desired level of capital K^+ is:

$$K^+ = \alpha \frac{pQ}{c}, \tag{12}$$

where p is the price of output, Q its quantity, c the rental price of capital, and α the elasticity of output with respect to capital. We assume that the flow of capital services is proportional to capital stock. This completes the determination of desired capital.[9]

To complete the theory of investment behavior it is necessary to specify the relationship between changes in desired capital and actual investment expenditures. After a change in the desired level of assets, plans must be formulated, funds appropriated, orders and contracts let, and so on. We assume that subsequent to a change in desired capital, a certain proportion of the resulting investment expenditure takes place over each interval of time. This proportion may vary by class of asset but is independent of calendar time.[10]

Second, we must specify the theory of replacement investment. We assume that subsequent to an investment a certain proportion is replaced over each interval of time. Again, we allow this proportion to vary by class of asset, but assume it to be independent of calendar time. Under our earlier assumption of a constant rate of replacement, investment for replacement is proportional to capital stock. This assumption implies an exponential survival curve for capital goods.[11]

Under these assumptions the theory of investment behavior takes the form of a distributed lag function; in discrete form this function may be written:

$$I_t = \sum_{s=0}^{\infty} \mu_s \Delta K^+_{t-s} + \delta K_t. \tag{13}$$

Gross investment in period t, I_t, is the sum of a weighted average of past changes in desired capital and replacement investment. The change in desired capital in period $t-s$ is ΔK^+_{t-s}; the parameter μ_s is the proportion of the change in desired capital in period $t-s$ that results in investment expenditures in period t. Replacement investment is proportional to capital stock K_t; the constant of proportionality is δ, the rate of replacement. An alternative and equivalent form of the distributed lag

[9] A more detailed derivation of desired capital stock is given in "Anticipations and Investment Behavior," [11, pp. 43–53].

[10] This theory of investment is discussed in more detail in "Anticipations and Investment Behavior," [11, pp. 46–50].

[11] See "Anticipations and Investment Behavior," [11, p. 51].

function gives net investment N_t as a weighted average of past changes in desired capital stock:

$$N_t = I_t - \delta K_t, \tag{14}$$
$$= \sum_{s=0}^{\infty} \mu_s \Delta \overset{+}{K}_{t-s}.$$

To estimate the parameters of the distributed lag function, it is necessary to impose further restrictions on the sequence of coefficients $\{\mu_s\}$. We have taken the first two coefficients of this sequence to be arbitrary with the remaining coefficients declining in a geometric series. The final form of the resulting distributed lag function is:

$$N_t = \gamma_0 \Delta \overset{+}{K}_t + \gamma_1 \Delta \overset{+}{K}_{t-1} - \omega N_{t-1}, \tag{15}$$

where γ_0, γ_1, and ω are parameters that characterize the sequence $\{\mu_s\}$. Adding an independently and identically distributed random term ϵ_t to the final form, we obtain the regression function:

$$N_t = \alpha\gamma_0 \Delta \frac{p_t Q_t}{c_t} + \alpha\gamma_1 \Delta \frac{p_{t-1} Q_{t-1}}{c_{t-1}} - \omega N_{t-1} + \epsilon_t, \tag{16}$$

where α is the elasticity of output with respect to capital. The parameters γ_0, γ_1, ω and α are unknown and must be estimated.[12] This investment function provides the basis for the statistical results reported in the following section.

To summarize, investment in period t depends on the capital stock at the beginning of the period and changes in the desired level of capital stock in previous periods. The form of the relationship depends on the parameters of the distributed lag function and the rate of replacement. Desired capital depends in turn on the value of output, the rental value of capital input, and the elasticity of output with respect to capital input.

The effects of tax policy on investment behavior enter the investment function through the rental value of capital input. A change in tax policy changes the rental value of capital input. This results in a change in the desired level of capital stock. A change in desired capital stock results in net investment (or disinvestment), bringing capital stock up (or down) to its new desired level. If there are no further changes in tax policy or in the other determinants of desired capital stock, net investment eventually drops to zero. The change in tax policy continues to affect gross investment through replacement of a permanently larger (or smaller) capital stock.

[12] Methods of estimation for such a distributed lag function are discussed by D. W. Jorgenson [13].

Our procedure is, first, to estimate the investment functions under the tax policies that actually prevailed. The results are given in the following section. Second, we employ the estimated investment functions to calculate the investment resulting from alternative tax policies. These calculations are given in Section III. We then analyze the results in order to assess the effectiveness of tax policy in changing the level and timing of investment expenditures. We also study the effects of tax policy on the distribution of investment between plant and equipment.

II. *Estimates of the Parameters of the Investment Function*

To implement the theory of investment behavior outlined in the preceding section, we have fitted the corresponding econometric model to data on investment expenditures from the Capital Goods Study of the Office of Business Economics (OBE).[13] Data are available for structures and equipment separately and for both manufacturing and non-farm, non-manufacturing sectors of the U.S. economy for the years 1929–63. These data are derived by allocating the commodity flow data on gross private domestic investment from the national product accounts among sectors of destination.

Estimates of capital stock at the beginning of each period K_t, were obtained by applying the following recursion relation to the investment data described above:

$$K_t = I_{t-1} + \delta K_{t-1}, \tag{17}$$

where I_t is investment in current prices deflated by an investment goods price index and δ is the rate of replacement, taken to be 2.5 times the inverse of the Bulletin F [21] lifetime. The following values were used for δ:

manufacturing equipment	0.1471
manufacturing structures	0.0625
non-farm, non-manufacturing equipment	0.1923
non-farm, non-manufacturing structures	0.0694

Initial values for capital stock were estimated by cumulating net investment over the whole period for which data are available for each asset.

Published price indexes for gross private domestic investment are biased because to a considerable extent they measure the prices of inputs to the capital goods industries rather than the price of output. To overcome this bias, we used price indexes based on output prices that are close substitutes in production for producers' durables and business structures—the implicit deflator for consumers' durables from the national product accounts and the Bureau of Public Roads price index for

[13] The OBE Capital Goods Study is reported by George Jaszi, Robert Wasson, and L. Grose [10]. More recent data were kindly supplied by Mr. Robert Wasson of the OBE.

structures.[14] For the years before these indexes are available we used the indexes implicit in the OBE Capital Goods Study, adjusted for bias in the rate of growth. The biases were estimated by regression which yielded the following values: 0.00651 per year for equipment and 0.0183 per year for structures.

The effects of tax policy enter the investment function through the desired level of capital stock. To estimate the desired level we used value added at factor cost as a measure of output p_tQ_t. We calculated value added for manufacturing and non-manufacturing, non-farm sectors by adding estimates of capital consumption allowances to national income originating in each sector.[15]

The desired level of capital stock also depends on the rental value of capital input c_t. Through 1953 the appropriate rental value of capital services corresponds to straight-line depreciation. Since 1954 the appropriate rental value corresponds to sum of the years' digits depreciation. Until 1962 the investment tax credit k is equal to zero. For 1962 and 1963 this credit is 7 per cent of the value of investment goods. In the formulas for the rental value of capital goods, the tax rate u, the after-tax rate of return r, the investment goods price q, and the lifetime of capital goods allowable for tax purposes τ are variables. The rate of replacement δ is a fixed parameter. The values of this parameter are the same as those employed in calculating capital stock.

We took the corporate tax rate to be the statutory rate prevailing during most of the year. We did not attempt to allow for excess profits taxes during the middle thirties or the Korean War. For the discount

[14] The implicit deflators for structures from the U.S. national accounts are primarily indexes of the cost of input rather than the price of output. The Bureau of Public Roads index for structures is based on the price of output; D. C. Dacy [4] has derived price indexes for road construction based on input and output prices. His index for the price of output grows from 80.5 to 98.2 from 1949 through 1959 while the price of input grows from 61.5 to 102.4 in the same period, both on a base of 100.0 in 1958. The implicit deflator for new construction in the national accounts grows from 51.3 to 103.0 in the same period. Although there is no real alternative to the Bureau of Public Roads index as an output price for structures, it is reassuring to find that the corresponding input price behaves in a manner very similar to that of the input price for all of new construction.

The price indexes for equipment from the U.S. national accounts are based on data from the wholesale price index of the Bureau of Labor Statistics. Since expenditures in the wholesale price index are less than those on the consumer's price index, adjustments for quality change are less frequent and less detailed. Some notion of the resulting bias in the growth of the implicit deflator for producers' durables can be obtained by comparing this index with the implicit deflator for consumers' durables. The producers' durables deflator increased from 64.6 in 1947 to 102.0 in 1959. Over this same period the deflator for consumers' durables increased from 82.7 to 101.4. Both indexes are computed relative to a base of 100.0 in 1958. A direct comparison of the durables components of the wholesale and consumers' price indexes reveals essentially the same relationship.

For further discussion, see Zvi Griliches and D. W. Jorgenson [9].

[15] All data are from the U.S. national accounts; see: U.S. Dept. of Commerce [20] and *Survey of Current Business* [18].

rate before taxes we used the figure of .14 throughout the period. Although there is little evidence that this rate varies over the period of fit, except for cyclical fluctuations, this rate appears to be somewhat conservative.[16] Estimates of lifetimes of assets allowable for tax purposes were obtained separately for assets acquired before 1954 and during and after 1954 from a special Treasury study [23]. The change between the two periods was divided equally between 1954–55 and 1955–56. For 1962 and 1963 the proportional change for the new guidelines relative to existing practice as estimated by the Treasury [24] was applied to the 1961 lifetimes for equipment. Lifetimes assumed were as follows:

Period	Equipment	Structures
1929–54	17.5	27.8
1955	16.3	25.3
1956–61	15.1	22.8
1962–63	13.1	22.8

Investment functions for equipment and structures for both manufacturing and non-farm, non-manufacturing sectors of the U.S. economy for the years 1931–41 and 1950–63[17] are presented in Table 2. The coeffi-

Table 2—Investment Functions for Manufacturing and Non-Farm, Non-Manufacturing Equipment and Structures for 1931–41, 1950–63

	$\Delta(pQ/c)_t$	$\Delta(pQ/c)_{t-1}$	N_{t-1}	$\hat{\alpha}$	Mean Lag	R_N^2	R_I^2	d
Manufacturing equipment	.01419 (.00372)	.01242 (.00442)	.6152 (.1001)	.0691 (.0156)	2.065 (.258)	.7219	.9566	2.036
Manufacturing structures	.00396 (.00131)	.00526 (.00145)	.7658 (.0790)	.0394 (.0126)	3.840 (.343)	.8475	.9208	2.474
Non-farm, non-manufacturing equipment	.02452 (.00844)	.01460 (.01038)	.4692 (.1342)	.0737 (.0141)	1.257 (.261)	.6899	.9616	1.738
Non-farm, non-manufacturing structures	.01296 (.00197)	.00227 (.00223)	.8801 (.0322)	.1269 (.0250)	7.488 (.239)	.9830	.9908	1.435

cients associated with $\Delta(p_tQ_t)/c_t$ and $\Delta(p_{t-1}Q_{t-1})/c_{t-1}$, respectively, are estimates of the $\alpha\gamma_0$ and $\alpha\gamma_1$. The coefficient associated with lagged net investment, N_{t-1}, is an estimate of $-\omega$. Using the fact that the coefficients of the distributed lag function sum to unity, an estimate of the elasticity of output with respect to capital may be obtained. This estimate, $\hat{\alpha}$, is also presented in Table 2.

Second, the average lag between changes in desired capital and actual investment expenditure as derived from the coefficients of the distributed lag function is presented in Table 2. Finally, Table 2 contains measures of the goodness of fit of the regression—R_I^2, R_N^2, and d, the Durbin-Watson ratio. Goodness of fit is measured in two ways: the ratio

[16] A figure suggested by the results of Jorgenson and Griliches [9] is 20 per cent before taxes. This figure excludes capital gains whether realized or unrealized.

[17] The years 1942–1947 are eliminated from the regressions because of the widespread use of nonprice allocation of capital goods during these years.

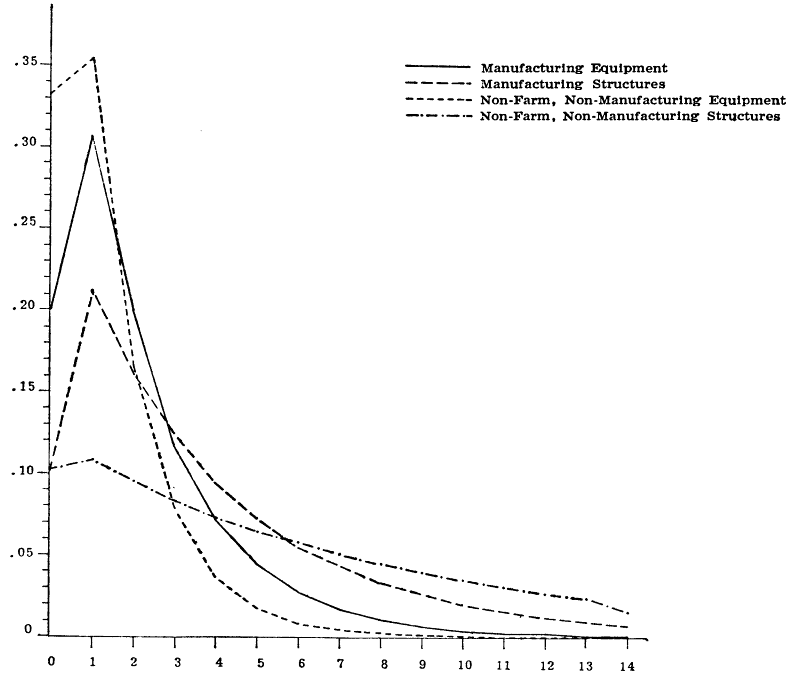

FIGURE 1

of the explained sum of squares to the total sum of squares for gross investment, R_I^2; the ratio of the explained sum of squares to the total sum of squares in net investment, R_N^2. Of course, gross investment is the variable of interest for policy considerations.

Estimates of the coefficients of the distributed lag function $\{\mu_s\}$ may be calculated from estimates of the parameters γ_0, γ_1, and ω by the usual recursion formula.[18] The first fifteen terms of the sequence $\{\mu_s\}$ derived by this technique are presented in Figure 1. The general shape of the distributed lag functions coincides with previous results based on quarterly data. A substantial part of the investment takes place during the year in which the change in desired capital occurs. However, even more occurs in the following year. By assumption the proportions of investment that result from a given change in desired capital decline geometrically in subsequent years. The average lag for investment in equipment is approximately 2 years for manufacturing and about 1.3 years for non-manufacturing. The average lag for structures is considerably longer, ranging from 3.8 years in manufacturing to 7.5 years in non-manufacturing.

[18] This formula is given in D. W. Jorgenson [13].

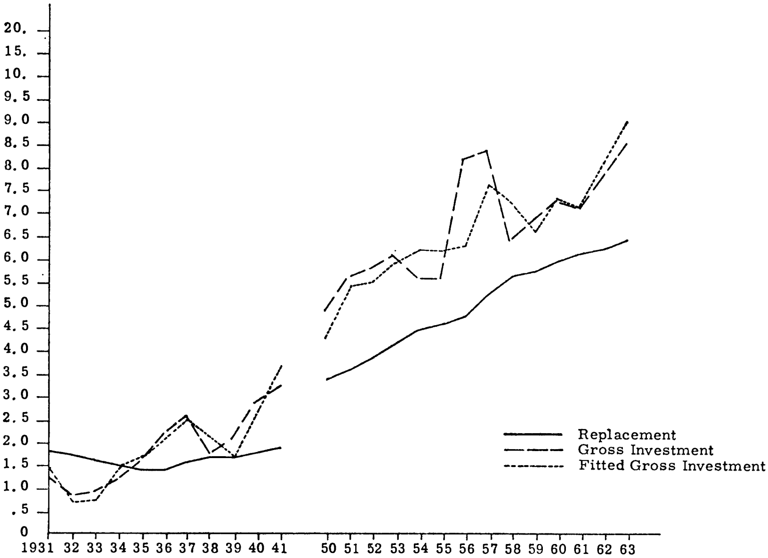

FIGURE 2a. MANUFACTURING EQUIPMENT

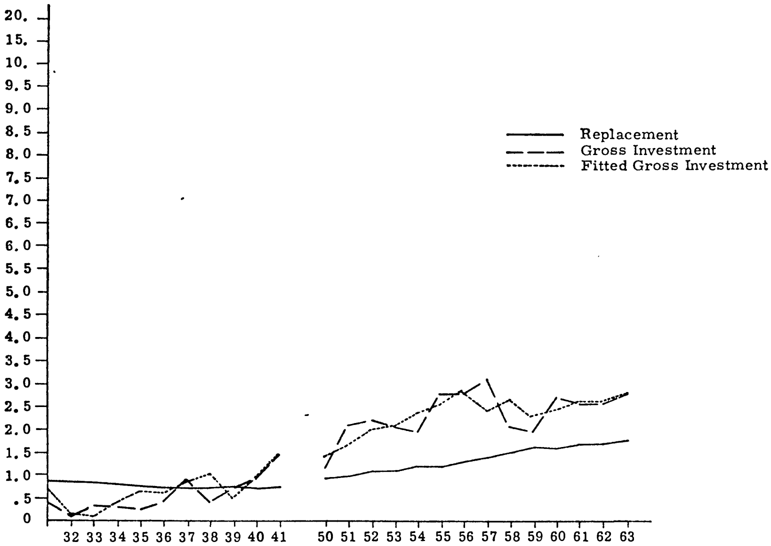

FIGURE 2b. MANUFACTURING STRUCTURES

To give a better notion of the degree of conformity between fitted values of investment and the actual observations, fitted gross investment is plotted against actual gross investment in Figures 2a–2d. Net investment is calculated from the fitted regression; replacement invest-

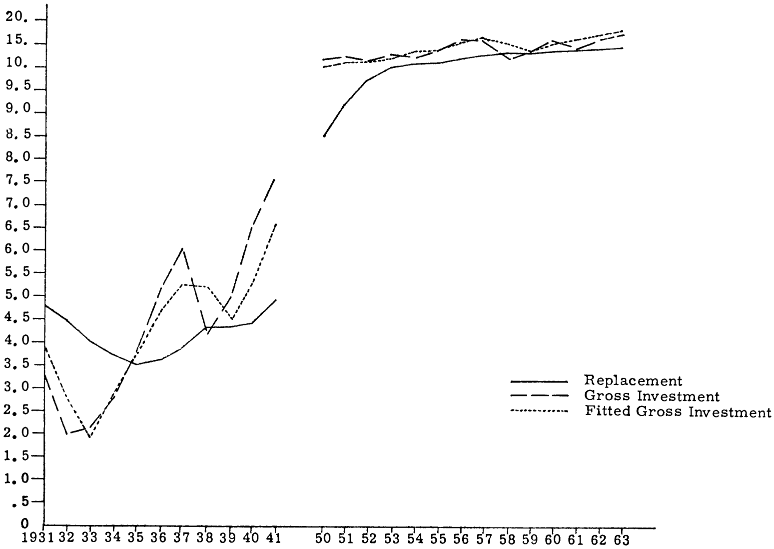

FIGURE 2c. NON-FARM, NON-MANUFACTURING EQUIPMENT

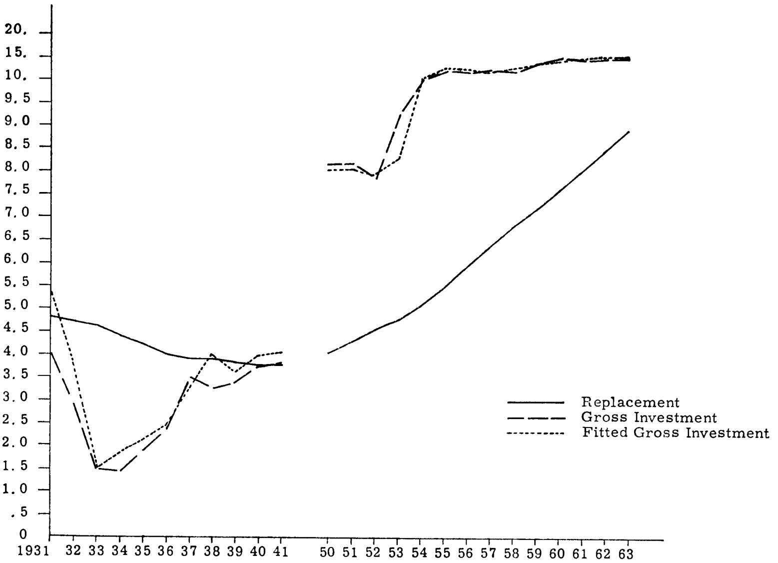

FIGURE 2d. NON-FARM, NON-MANUFACTURING STRUCTURES

ment, taken as a given datum, is then added to obtain the fitted value of gross investment. Data on replacement investment are also plotted in Figures 2a–2d. Despite the wide variability in levels of gross investment during the period 1931 and 1963, the fitted investment functions provide an accurate representation of actual investment behavior. In almost every series the largest observation is at least ten times the smallest, so that the goodness of fit of the investment functions provides much stronger confirmation for the underlying theory of investment behavior than functions fitted to postwar data alone.

III. *The Effects of Tax Policy on Investment Behavior*

The effects of a change in tax policy are: (1) an initial burst of net investment which brings the capital stock up to the new desired capital stock, (2) a permanent increase in gross investment resulting from replacement of a larger capital stock, and (3) a proportionate increase in net and gross investment caused by changes in other determinants of desired capital stock. To calculate the magnitudes of these effects for various alternative policies, we have assumed that tax policy has no effect on the before-tax rate of return or on the price of capital goods.

We present results for three actual changes and for one hypothetical change in tax policy: (1) the adoption of accelerated methods for computing depreciation for tax purposes in 1954, (2) the shortening of lifetimes for tax purposes allowed for equipment by the depreciation guidelines of 1962, (3) the investment tax credit of 1962, and (4) the hypothetical adoption of first-year writeoff in 1954. For each of the actual changes in tax policy our procedure is to calculate the rental price of capital on the assumption that the change in policy did not take place. We then calculate the changes in desired capital and investment for the resulting rental price of capital. Desired capital and investment depend on the parameters of the investment function; in our calculations, these parameters are replaced by the estimates given in Table 2 above. For the hypothetical first-year writeoff of investment expenditures beginning in 1954 our procedure is to calculate the rental price of capital under this policy. We then calculate the resulting changes in desired capital and investment from the fitted investment functions, as before.

The reductions in the rental on capital goods brought about in 1954 as a result of accelerated depreciation were as follows:

	Before Change	After Change
Manufacturing Equipment	.310	.284
Manufacturing Structures	.207	.188
Non-Farm, Non-Manufacturing Equipment	.375	.344
Non-Farm, Non-Manufacturing Structures	.218	.198

Our estimates of the increase in net investment, gross investment, and capital stock resulting from this change are given in Table 3. For comparison the actual levels of net investment, gross investment, and capital stock are given in Table 4.

TABLE 3—CHANGE IN NET INVESTMENT, GROSS INVESTMENT, AND CAPITAL STOCK RESULTING FROM ACCELERATED DEPRECIATION, 1954–63
(billions of 1954 dollars)

Year	Manufacturing Equipment			Manufacturing Structures			Non-Farm Non-Manufacturing Equipment			Non-Farm Non-Manufacturing Structures		
	N	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*
1954	.418	.418	0	.189	.189	0	1.059	1.059	0	1.045	1.045	0
1955	.680	.742	.418	.434	.446	.189	1.214	1.417	1.059	1.246	1.319	1.045
1956	.480	.641	1.098	.367	.406	.623	.683	1.120	2.273	1.076	1.236	2.291
1957	.305	.537	1.579	.258	.320	.990	.386	.954	2.957	.955	1.189	3.368
1958	.154	.431	1.884	.186	.264	1.249	.220	.863	3.343	.896	1.196	4.324
1959	.124	.423	2.038	.169	.259	1.436	.202	.887	3.564	.954	1.316	5.220
1960	.133	.451	2.162	.190	.290	1.605	.201	.926	3.766	.959	1.388	6.175
1961	.089	.427	2.296	.154	.266	1.796	.193	.956	3.968	.904	1.399	7.134
1962	.127	.478	2.385	.127	.249	1.950	.274	1.074	4.161	.833	1.391	8.038
1963	.179	.549	2.513	.125	.255	2.078	.288	1.141	4.435	.765	1.381	8.872

TABLE 4—ACTUAL LEVELS OF NET INVESTMENT, GROSS INVESTMENT, AND CAPITAL STOCK, 1950–63
(billions of 1954 dollars)

Year	Manufacturing Equipment			Manufacturing Structures			Non-Farm Non-Manufacturing Equipment			Non-Farm Non-Manufacturing Structures		
	N	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*
1950	1.522	4.917	23.081	.257	1.240	15.726	3.579	12.086	44.238	4.172	8.141	57.189
1951	1.985	5.604	24.603	1.101	2.100	15.983	3.301	12.496	47.817	3.925	8.183	61.361
1952	1.839	5.750	26.588	1.093	2.161	17.084	2.499	12.329	51.119	3.345	7.876	65.287
1953	1.914	6.096	28.428	.974	2.110	18.178	3.041	13.352	53.618	4.539	9.302	68.633
1954	1.148	5.612	30.342	.841	2.039	19.152	1.692	12.588	56.659	5.589	10.668	73.172
1955	.961	5.593	31.491	1.504	2.754	19.994	3.061	14.282	58.352	7.135	12.601	78.761
1956	3.398	8.171	32.452	1.478	2.822	21.499	4.633	16.443	61.413	6.041	12.002	85.897
1957	3.159	8.432	35.850	1.682	3.119	22.978	3.829	16.530	66.047	5.739	12.119	91.938
1958	.672	6.410	39.009	.593	2.134	24.661	.614	12.822	69.876	5.340	12.119	97.677
1959	1.013	6.850	39.682	.391	1.969	25.255	1.396	14.715	69.261	6.047	13.196	103.010
1960	1.314	7.301	40.695	1.141	2.744	25.646	2.723	16.311	70.658	6.911	14.480	109.060
1961	.921	7.101	42.010	.980	2.654	26.788	.840	14.951	73.382	6.585	14.634	115.970
1962	1.428	7.744	42.931	.900	2.635	27.768	2.790	17.063	74.222	6.242	14.748	122.560
1963	1.935	8.461	44.360	1.057	2.849	28.668	3.172	17.982	77.012	5.878	14.817	128.800

The effects of the switch to accelerated methods for computing depreciation are quite dramatic. For each of the four classes of assets, the change in depreciation rules results in a substantial increase in desired capital stock. The effects of this increase depend on the time lag between changes in desired capital stock and the resulting net investment.

Although essentially the same pattern prevails for all four classes of assets, it is useful to trace out the effects of tax policy on net investment, gross investment, and capital stock for each class. The peak effect on net investment for manufacturing equipment is attained in 1955 with a level of $.680 billion (in constant 1954 dollars) or 70.8 per cent of net investment in that year. By 1961, the increase in net investment has fallen to $.089 billion. Over the whole period 16.9 per cent of the net investment in manufacturing equipment may be attributed to the change in depreciation rules. Similarly, the peak effect for non-farm, non-manufacturing equipment is $1.214 billion in 1955, or 39.7 per cent of the net investment that took place in that year. Over the 1954–63 period 19.1 per cent of the net investment in non-farm, non-manufacturing equipment may be attributed to the change in depreciation rules. By 1961, the increase in net investment has fallen to $.193 billion.

The pattern of net investment for structures is similar to that for equipment. For manufacturing structures the peak effect on net investment occurs in 1955 with $.434 billion or 28.9 per cent of the net investment that took place in that year. The decline of net investment in structures is more gradual. By the end of the 1954–63 period the increase in net investment in manufacturing structures due to the change indepreciation rules in 1954 is still $.125 billion. Over the whole period 20.8 per cent of net investment may be attributed to the change in depreciation policy. For non-farm, non-manufacturing structures the peak effect on net investment is in 1955 with $1.246 billion or 17.5 per cent of the net investment that took place. This level falls off to $.765 billion by 1963, the end of the ten-year period, 1954–63. Over the whole period 15.7 per cent of the net investment in non-farm, non-manufacturing structures may be attributed to the change in depreciation rules.

Since capital stock is simply a cumulation of net investment, the pattern of its behavior may be deduced from that for net investment. For both manufacturing and non-farm, non-manufacturing equipment capital stock rises rapidly over the levels that would have prevailed during the first few years following the adoption of accelerated depreciation methods. More than half of the increase over the period, 1954–63, had already occurred for manufacturing by 1957 and for non-farm, non-manufacturing by 1956. The rise in capital stock for structures is more gradual. Half of the total increase had occurred for manufacturing by 1958 and for non-farm, non-manufacturing by 1959.

Turning to the effects of accelerated depreciation on gross investment, we recall that gross investment is simply the sum of net investment and replacement and that replacement rises in proportion to capital stock. Replacement becomes the dominant component of gross investment in equipment by 1958 for manufacturing and by 1957 for non-farm, non-manufacturing. In both sectors gross investment rises to a peak in 1955 with net investment predominating. As net investment declines, replacement investment rises so that gross investment remains nearly stationary at levels somewhat below the 1955 peak. In manufacturing the increase in gross investment due to accelerated depreciation is $.549 billion in 1963, which may be compared with the peak level of $.742 billion in 1955. Similarly, in the non-farm, non-manufacturing sector the increase in gross investment due to accelerated depreciation is $1.141 billion in 1963, compared with a peak of $1.417 billion in 1955. The pattern in manufacturing structures is similar to that for equipment. The peak level of investment of $.446 billion is attained in 1955; the 1963 level is $.255 billion. For non-farm, non-manufacturing structures net investment continues at a high level throughout the period so that gross investment is roughly constant from 1959 to 1963, when the level is $1.381 billion. This level may be compared with the relative peak of $1.319 billion in 1955.

The effect of accelerated depreciation on gross investment during the 1954–63 period may be seen by calculating investment resulting from accelerated depreciation as a proportion of the total investment that took place. For equipment 7.1 per cent of gross investment in manufacturing and 6.8 per cent of the gross investment in non-farm, non-manufacturing may be attributed to accelerated depreciation over the period, 1954–63. For structures the percentages are 11.4 for manufacturing and 9.8 for non-farm, non-manufacturing. Another perspective on the effect of the depreciation rules may be obtained by calculating the proportion of gross investment resulting from the change to total investment at the end of the period. For manufacturing equipment 6.5 per cent of gross investment in 1963 is a result of accelerated depreciation; the corresponding percentage for non-farm, non-manufacturing equipment is 6.3 per cent. The effects of the change are more significant in structures. In 1963, 9.0 per cent of gross investment in manufacturing structures could be attributed to accelerated depreciation; similarly, in non-farm, non-manufacturing structures 9.3 per cent of gross investment could be attributed to the change in depreciation rules.

In 1962 new guidelines for the determination of lifetimes allowable for tax purposes were issued [23]. These guidelines involved a substantial reduction in equipment lifetimes allowable for tax purposes. The reductions in the rental on capital goods which the change in guidelines brought about in 1962 were as follows:

	Before Change	After Change
Manufacturing Equipment	.273	.267
Non-Farm, Non-Manufacturing Equipment	.331	.323

We have calculated the effects on net investment, gross investment, and capital stock resulting from the depreciation guidelines of 1962. These calculations give the increase in equipment investment over the levels that would have prevailed had lifetimes remained at their 1961 levels. The results are given in Table 5.

TABLE 5—CHANGE IN NET INVESTMENT, GROSS INVESTMENT, AND CAPITAL STOCK RESULTING FROM 1962 DEPRECIATION GUIDELINES AND THE INVESTMENT TAX CREDIT, 1962–63
(billions of 1954 dollars)

Year	1962 Depreciation Guidelines						Investment Tax Credit					
	Manufacturing Equipment			Non-Farm Non-Manufacturing Equipment			Manufacturing Equipment			Non-Farm Non-Manufacturing Equipment		
	N	I	K	N	I	K	N	I	K	N	I	K
1962	.185	.185	0	.504	.504	0	.509	.509	0	1.388	1.388	0
1963	.287	.315	.185	.559	.656	.504	.792	.867	.509	1.541	1.808	1.388

The impact of the revised guidelines is substantial, though not as dramatic as the shift to accelerated methods of depreciation in the Internal Revenue Code of 1954. The impact is limited to equipment, whereas the effects of accelerated depreciation were much greater for structures than for equipment. The peak response to the new guidelines, occurring in 1963, is less than half the peak response of investment in equipment to the switch to accelerated depreciation. In percentage terms 14.8 per cent of the net investment in manufacturing equipment in 1963 is due to the change in guidelines; 17.6 per cent of the net investment in non-farm, non-manufacturing equipment is due to the change. The impact on gross investment is proportionately smaller. In 1963 only 3.7 per cent of gross investment in manufacturing equipment is due to the new guidelines; 3.6 per cent of investment in non-farm, non-manufacturing equipment could be attributed to the revised lifetimes.

A second change in tax policy during 1962 was the adoption of a seven per cent investment tax credit for machinery and equipment in the Revenue Act of 1962.[19] Seven per cent of the value of purchases of new

[19] Actually, limitations making the tax credit inapplicable to very short-lived assets reduce its effective rate to about 6.6 per cent. In 1964 its effective rate was raised to around ten per cent by allowing depreciation to be taken on the cost before rather than after the tax credit.

plant and equipment is a credit against tax liability. The depreciation base is reduced by the amount of the tax credit. The remaining 93 per cent is then amortized over the lifetime of the equipment. The reductions in the rental on capital goods which the investment tax credit brought about in 1962 were as follows:

	Before Change	After Change
Manufacturing equipment	.286	.267
Non-farm, non-manufacturing equipment	.346	.323

To isolate the effects of the investment tax credit, we have calculated the resulting net investment, gross investment, and capital stock. These calculations give the increase in investment over levels that would have prevailed in the absence of the investment tax credit. This increase is given in Table 5.

The effects of a 7 per cent investment tax credit are quite startling. Although the impact is limited to equipment, the peak response of net investment to the tax credit, occurring in 1963, is greater for both manufacturing and non-farm, non-manufacturing than the response to accelerated methods of depreciation. Fully 40.9 per cent of the net investment in manufacturing equipment in 1963 can be attributed to the investment tax credit. The corresponding percentage for non-farm, non-manufacturing equipment is 48.6 per cent. Of course, the impact of the investment tax credit on gross investment is less startling, but this impact is also quite dramatic. Of the total of $8.461 billion of investment in manufacturing equipment in 1963, 10.2 per cent can be traced to the effects of the investment tax credit. Similarly, of $17.982 billion of investment in non-farm, non-manufacturing equipment in the same year, 10.1 per cent can be attributed to the investment tax credit. There can be little doubt that an investment tax credit is a potent stimulus to investment expenditure.

The progressive liberalization of depreciation for tax purposes since 1954 has had an important impact on investment behavior. The investment booms of 1955–57 and beginning in 1962 reflect, in part, the response of investment behavior to the changes in tax policy that took place in 1954 and 1962. According to our calculations, the adoption of accelerated depreciation in the Internal Revenue Code of 1954 resulted in a shift in the composition of investment from equipment to structures. Similarly, the adoption in 1962 of new guidelines and the investment tax credit resulted in a shift of investment from structures to equipment. This shift was especially dramatic for the response to the investment tax credit.

The magnitude of the past response to liberalization of depreciation suggests an investigation of the response to further liberalization. To take an extreme assumption we can investigate the pattern of investment that would result from complete "expensing" or first-year writeoff of investment. Under such a tax policy expenditures on capital account would be treated in the same way as expenditures on current account. As Vernon Smith [17] has demonstrated, the effects of this policy are the same as the effects of no taxation of business income.[20] The reductions in the rental on capital goods which first-year writeoff would have brought about in 1954 are as follows:

	Before Change	After Change
Manufacturing Equipment	.284	.214
Manufacturing Structures	.188	.130
Non-Farm, Non-Manufacturing Equipment	.344	.260
Non-Farm, Non-Manufacturing Structures	.198	.137

We have calculated the effects on net investment, gross investment, and capital stock resulting from the hypothetical adoption of first-year writeoff in 1954. The changes represent the increment in investment and capital stock over the levels that resulted from accelerated depreciation. The increases in net investment, gross investment, and capital stock are presented in Table 6.

The adoption of first-year writeoff for investment expenditures in 1954 would have resulted in a sharp rise in desired capital for all four classes of assets. The effect of this rise on investment is relatively rapid for equipment; for manufacturing net investment in equipment for 1955 would have been over twice as large as a result of first-year writeoff. The relative increase in equipment investment in the non-farm, non-manufacturing sector would have been somewhat smaller. The increase in net investment in equipment for both sectors would have returned to relatively moderate levels by the beginning of the 1960's. The response is much more gradual for structures than for equipment. The increase in net investment in structures would have remained at substantial levels throughout the 1950's and 1960's. The effects of adoption of first-year writeoff in 1954 on gross investment in both equipment and structures would have been substantial throughout the period 1954–63. By the end of the period the chief effect of this policy would have been an increased level of replacement investment.

IV. *Conclusion*

We have calculated the effects of changes in tax policy on investment behavior for three major tax revisions in the postwar period: (1) the adoption of accelerated methods for calculating depreciation in the Internal Revenue Code of 1954; (2) the reduction of lifetimes used for calculating depreciation on equipment and machinery in 1962; (3) the

[20] See also R. A. Musgrave [16].

TABLE 6—CHANGE IN NET INVESTMENT, GROSS INVESTMENT, AND CAPITAL STOCK RESULTING FROM HYPOTHETICAL ADOPTION OF FIRST-YEAR WRITEOFF OF INVESTMENT EXPENDITURES, 1954–63
(billions of 1954 dollars)

Year	Manufacturing Equipment			Manufacturing Structures			Non-Farm Non-Manufacturing Equipment			Non-Farm Non-Manufacturing Structures		
	N	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*	*N*	*I*	*K*
1954	1.606	1.606	0	.937	.937	0	4.071	4.071	0	5.168	5.168	0
1955	2.555	2.791	1.606	2.085	2.144	.937	4.519	5.302	4.071	5.842	6.201	5.168
1956	1.692	2.304	4.161	1.633	1.822	3.023	2.310	3.962	8.591	4.691	5.455	11.011
1957	1.023	1.884	5.853	1.072	1.363	4.657	1.233	3.329	10.901	4.106	5.196	15.702
1958	.508	1.520	6.877	.769	1.127	5.730	.719	3.053	12.134	3.858	5.233	19.809
1959	.417	1.504	7.385	.706	1.112	6.499	.691	3.163	12.854	4.126	5.768	23.668
1960	.463	1.611	7.803	.807	1.258	7.205	.708	3.313	13.546	4.157	6.086	27.794
1961	.311	1.527	8.267	.656	1.157	8.013	.685	3.426	14.254	3.921	6.138	31.952
1962	.328	1.590	8.578	.544	1.086	8.670	.642	3.515	14.940	3.617	6.107	35.873
1963	.447	1.757	8.906	.538	1.114	9.214	.656	3.652	15.582	3.325	6.066	39.491

investment tax credit for equipment and machinery in the Revenue Act of 1962. The effects of accelerated depreciation are very substantial, especially for investment in structures. The effects of the depreciation guidelines of 1962 are significant, but these effects are confined to investment in equipment. The effects of the investment tax credit of 1962 are quite dramatic and leave little room for doubt about the efficacy of tax policy in influencing investment behavior. These three tax policies represent a progressive liberalization of depreciation for tax purposes. To get some idea of the effects of further liberalization we have calculated the impact of the adoption of first-year writeoff of investment expenditures beginning in 1954. This tax policy represents the ultimate liberalization since it is equivalent to treating capital expenditures in the same way as current expenditures for tax purposes. The effects of such a policy on investment expenditure would have been very substantial throughout the period, 1954–63.

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