The Cost of Capital, The Desired Capital Stock, and a Variable Investment Tax Credit as a Stabilization Tool

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This study considers the potential of a variable investment tax credit to relieve the pressure of a contracyclical monetary policy on the housing and State and local government sectors. In particular, it examines the potential of such a policy instrument to affect business capital expenditures in the U. S. manufacturing sector at the two-digit SIC (Standard Industrial Classification) level of aggregation. If a variable investment tax credit can affect investment expenditures with sufficient force and speed, the active use of such a policy instrument could reduce the stabilization burden now borne by the housing and State and local government sectors.

Perhaps the best known recent works in this area are those by Hall and Jorgenson (11,12,13) and Bischoff (2). The model used by Hall and Jorgenson assumes that the elasticity of the desired capital stock with respect to the implicit rental rate on capital is unity, that is, it is an assumed rather than an estimated value. In addition, their model has a theoretical difficulty which recent research [6] has found to be of empirical consequence. Essentially this difficulty stems from attempting to explain the demand for an input, capital, by use of output in a single equation model. Bischoff's model is more general than that used by Hall and Jorgenson in that it assumes a CES production function, instead of Cobb-Douglas, and it is a putty-clay model as opposed to a putty-putty model. Bischoff's model still has the same theoretical difficulty alluded to above, however. Furthermore, his model must be estimated by nonlinear estimation tech-

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niques the statistical properties of which have not as yet been established except to a limited extent in certain asymptotic cases. Bischoff's as well as Hall and Jorgenson's empirical investigations of tax effects on investment behavior were conducted at a much more aggregative level than that undertaken in this study. Our model differs from both of these models in that: output specific to the industry is not used as an explanatory variable; the effects of labor costs on the demand for capital are explicitly taken into account. Our model differs from the Hall-Jorgenson model in that the elasticity of the desired capital stock with respect to the implicit rental rate on capital is a parameter to be estimated, rather than assumed to equal one. Our model differs from the Bischoff model in that ours is a putty-putty model assuming a Cobb-Douglas production function. Because of this we are able to use a linear estimation procedure whereas Bischoff's model must be estimated by nonlinear techniques. Undeniably, this gain is obtained by giving up some generality of specification. However, as regards the Cobb-Douglas assumption, Jorgenson's survey [14, pp. 1131-1133] of findings on this issue concludes that it is a tenable assumption.

In Section I we summarize the case that is commonly put forward for a variable investment tax credit scheme. Section II details the framework of analysis used in this study. Section III discusses estimation and related data problems, and presents our estimation results. In Section IV the policy implications of our findings are considered.

I. Monetary Policy and the Case for a Variable Investment Tax Credit

A major, often heard, complaint against heavy reliance on monetary policy to stabilize the economy is that its effectiveness places the major burden of adjustment on those sectors most sensitive to changes in general credit conditions. In particular, the housing and State and local government sectors appear among the most severely, some argue inequitably, penalized. Given the existing political and economic institutions, these sectors will continue to bear the cutting edge of monetary policy unless measures are instituted that will increase the responsiveness of other sectors to monetary stabilization policies.[1]

[1] A compendium of papers which examines possible measures to alleviate the problem in housing in particular, plus extensive bibliographies on the problem in general, may be found in [3].

There are a number of potential ways to reduce the burden of cyclical stabilization currently borne by the housing and/or State and local government sectors. Most have some severe drawbacks associated with them, however. For example, the notion of pursuing a more active contracyclical fiscal policy has not turned out to be very feasible in the United States. Allocation considerations have typically taken precedent over stabilization objectives in making Federal expenditure decisions, and the instigation and implementation of changes in general tax rate schedules has usually been a protracted process. Schemes designed to insulate the housing sector from the effects of changes in credit conditions would only serve to further exacerbate the effects of such changes on the State and local government sector, and schemes designed to insulate the latter would similarly worsen the burden on the housing sector. Schemes designed to buffer both sectors from the effects of changing credit conditions would reduce the impact of monetary policy on aggregate demand and therefore would require larger, probably unpalatable, fluctuations in interest rates and monetary aggregates to obtain the same effect on aggregate spending. Hence, extensive insulation of the housing and State and local government sectors would considerably compromise the efficacy of monetary policy as a stabilization tool.

Largely because of the above considerations, attention has been given to the design of policy instruments intended to affect business fixed investment in a contracyclical manner. Whatever the sources of fluctuations in aggregate economic activity, changes in the rate of business fixed investment have been a large and volatile component. If this component could be stabilized, reliance on conventional monetary policy could be reduced and this would help alleviate the burden of cyclical adjustment that is now borne by housing and State and local government construction activity. It appears that conventional monetary policy as conducted since the Treasury-Federal Reserve accord has found it difficult to exercise either a rapid or sizable influence over business fixed capital spending. This suggests that attempts to induce contracyclical movements in business fixed investment may require larger movements in interest rates and monetary aggregates than monetary policy has heretofore envisioned. But this would place an even more severe burden of adjustment on the housing and State and local government sectors. These considerations have motivated the search for a policy instrument specifically designed to directly affect business fixed investment expenditure while minimizing their impact on other sectors.

Such an instrument could be designed by using a system of business investment taxes and subsidies to pursue desired stabilization goals. Various traditional types of taxes could be imposed on investment during periods deemed excessively expansionary while investment tax credits might be offered during recessionary periods. Because it is typically difficult to get rapid congressional approval of such discretionary measures, it would be necessary that such a scheme be endowed with formula flexibility, with circumscribed discretionary authority vested either in the executive branch of government or the Federal Reserve System in order that the primary function and purpose of the scheme may be to pursue stabilization goals. For lack of a better name, such a policy instrument may be called a variable investment tax credit.[2]

In the context of a neoclassical theory of factor demand, such as developed by Haavelmo [10] and Jorgenson[15], it can be shown that a variable investment tax credit (VITC) can change the effective factor demand for capital equipment by altering the implicit rental rate or own price of capital. If a VITC scheme is to be a useful stabilization tool, two conditions must be satisified to some reasonable degree: first, the demand for capital should be sensitive to changes in the implicit rental rate of capital; second, the full impact of such changes must occur within a reasonable time after a change in the implicit rental rate occasioned by a change in the VITC. It is the purpose of this study to provide an empirical examination of both of these issues for 12 out of 20 of the two-digit SIC industries comprising total U. S. manufacturing (see Table I): with regard to the sensitivity of the desired capital stock to changes in the implicit rental rate of capital, elasticity estimates are obtained; with regard to lag lengths, distributed lags are estimated to attempt to ascertain how long it takes for the impact of a change in the implicit rental rate of capital to be fully realized.

[2]An alternative approach has been suggested by Pierce and Tinsley [3, pp. 345-355]. They propose the establishment of a business investment fund (BIF) having a unit deposit or withdrawal rate geared to the level of aggregate fixed investment expected relative to the expenditure level deemed necessary for economic stabilization; the BIF rate would amount to a mark-up or rebate on the purchase price of new capital goods. A positive BIF rate would be applied to gross fixed investment expenditures during periods of excess aggregate demand, thereby effectively raising the price of new capital goods and discouraging investment demand. During periods of deficient aggregate demand the BIF rate would be negative, the outpayments serving to effectively lower the price of new capital goods to investing firms. A similar scheme has been used in Sweden: see Lindbeck's paper in this volume.

TABLE 1

STANDARD INDUSTRIAL CLASSIFICATION

SIC No.	Industry
20	Food and Beverages
22	Textile Mill Products
26	Paper and Allied Products
28	Chemical and Allied Products
29	Petroleum and Coal Products
30	Rubber Products
32	Stone, Clay, and Glass
33	Primary Metals
34	Fabricated Metals
35	Nonelectrical Machinery
36	Electrical Machinery and Equipment
38	Instruments

If the lags appear to be "too long," a case can be made for administering the VITC scheme in such a way as to encourage business investment decision makers to speed up their attempts to put new capital in place. For example, if the policy maker publicly announces that an investment tax credit will be granted on all projects started between say time t and t+4 (a period of four months for example), decision makers would presumably try to take advantage of such a credit while it lasted. The closer the termination date is to t, the more "bunching" of investment expenditures would presumably occur in the time interval from t to t+j, where j is the termination date. By varying j the policy maker could in this way have an effect on the length of the lag between the change in the implicit rental rate of capital, caused by a change in the variable investment tax credit, and the point in time by which the impact of such a change on the desired stock of capital would be fully realized.

The purpose of a VITC scheme is to stabilize business fixed investment which, by virtue of its multiplier effects on aggregate demand, would serve to help stabilize the economy. Increased stability of the economy would in turn make the task of stabilizing investment that much easier by reducing the fluctuations in the feedback effects from the economy on investment – the well-known accelerator effect which aggregate economic fluctuations have on investment. This study obtains estimates of the strength of these feedbacks and the distributed lag lengths over which their impact on investment is fully realized. Hopefully this will shed some light on just how much the feedback effects of increased stability in the ecomony might aid a VITC scheme's task of stabilizing fluctuations in fixed business investment.

II. The Framework of Analysis – A Neoclassical Reduced Form Model

The model used in this study is derived from a microtheoretical analysis of a monopolistic producer. The model can then be extended to imperfectly competitive and perfectly competitive industries. The interpretation of the parameters is the same on an industry or firm level; and the market structure of the industry will not affect the interpretation of the results. The model has been used to analyze investment behavior by Gould and Waud [6], and a variant has been used by Waud [24] to study the demand for labor.

The Reduced Form

The following symbols are used in the derivation of the model to follow:

P = unit price of output Q;
Q = quantity of output;
s_1 = total cost per production worker hour;
s_2 = total cost per overhead worker hour;
L_1 = production worker hours;
L_2 = overhead worker hours;
q = price of capital goods;
K = capital stock employed;
K^* = capital stock desired;
I = gross capital formation;
T = corporate profit taxes;
R = time rate of discount;
u = corporate tax rate;
v = proportion of depreciation cost chargeable against net taxable income;
w = proportion of cost of capital chargeable against net taxable income;
x = proportion of capital gains on assets subject to taxation;
r = cost of capital;
δ = rate of depreciation.

In this version of the neoclassical model, it is assumed that the firm chooses its capital and labor inputs in such a manner as to maximize its net worth, or the present value of all future net receipts. It is also assumed that replacement investment is directly proportional to the capital stock of the firm.[3] Net investment is thus constrained by the relation.

$$(1) \qquad \dot{K} = I - \delta K \quad (\dot{f} = df/dt)$$

The firm's output is also constrained by the production possibilities embodied in the firm's production function

$$(2) \qquad F(K, L_1, L_2, Q) = 0 \ .$$

Net receipts at time t are equal to the algebraic sum of gross receipts, labor costs, capital costs, and taxes, where taxes are equal to the tax rate times the firm's net taxable income:

$$(3) \qquad T = u[PQ - s_1 L_1 - s_2 L_2 - vq\delta K - wqrK + x(\dot{q}/q)qK] \ .$$

In (3), $vq\delta K$ is the amount of depreciation chargeable against net income, $wqrK$ is the amount of capital cost chargeable against net income, and xqK is the amount of capital gains chargeable to net income. The unit cost of capital is assumed to be invariant with respect to the rate of investment. The cost of investment at the rate I is simply equal to the amount of capital investment per unit of time multiplied by the unit cost of capital goods. The labor inputs L_1 and L_2 are assumed to be sufficiently elastic so that the desired labor inputs can be realized in each period without any costs of adjustment.[4] Thus the cost functions for labor are simply equal to the labor inputs multiplied by their unit costs.

The firm will thus act so as to maximize

$$(4) \qquad V = \int_0^\infty e^{-Rt}[PQ - s_1 L_1 - s_2 L_2 - qI - T]\, dt$$

[3] For a discussion of this assumption, see Jorgenson [17, p. 139].

[4] It will be presumed that the demand for labor inputs for a two-digit industry constitutes a relatively small proportion of the total labor demand. Consequently, labor inputs can be adjusted to the desired level in each period with little cost of adjustment. Such an assumption is made by Waud [24].

subject to the constraints (1) and (2). We assume a Cobb-Douglas production function. Neutral technological change is introduced into the production function by assuming that the effective input from each factor is the product of that input and a proportionality factor which is a function of time. The proportionality factor in the production function is also a function of time. In this case, the proportionality factors are assumed to be exponential functions of time: $A_i(t) = A_i e^{g_i t}$ $(i = 0, \ldots, 3)$. Thus the production function can be expressed as

$$(5) \qquad Q = A_o(t)\left[A_1(t)K\right]^a \left[A_2(t)L_1\right]^b \left[A_3(t)L_2\right]^d$$
$$= Ae^{gt}K^aL_1^{\,b}L_2^{\,d} \qquad a,b,d > 0$$

where $A = A_oA_1^{\,a}A_2^{\,b}A_3^{\,d}$ and $g = ag_1 + bg_2 + dg_3$; it is assumed $g > 0$.

Substituting (3) and (5) into (4) and then obtaining the Euler first order conditions for a maximum, we get the following comparative static equilibrium values for capital and labor:[5]

$$(6) \qquad K = K^* = \frac{aQP}{c} \; ;$$

$$(7) \qquad L_1 = L_1^* = \frac{bQP}{s_1} \; ;$$

$$(8) \qquad L_2 = L_2^* = \frac{dQP}{s_2} \; ;$$

where c in (6) is the implicit rental on a unit of capital services, or the own price of capital, which from the Euler conditions can be shown to be

$$(9) \qquad c = q\left[\left(\frac{1 - uv}{1 - u}\right)\delta + \left(\frac{1 - uw}{1 - u}\right)r - \left(\frac{1 - ux}{1 - u}\right)\dot{q}/q\right].$$

Following Jorgenson [16, p. 59], it is assumed that the firm views all capital gains and losses on its capital stock as transitory. This assumption may be justified on the grounds that the manufacturing firm does not generally buy capital goods with the intention of realizing any capital gain which might arise due to changes in the prices of capital goods. The firm views all such capital gains as transitory and of no consequence in determining its cost of capital so that $(\dot{q}/q)$ can be equated to zero. From (6) and (9) it is now apparent how tax and credit schemes imposed on the firm enter into the determination of the desired capital stock through the own price of capital c, that is, by virtue of the presence of such policy determined tax parameters

[5]The details of this derivation may be obtained from the authors on request.

as u, v, and w in (9). It is through changes in just such parameters as these that a VITC scheme would work by changing c.

It is important to emphasize that (6) defines the long-run equilibrium value of capital, since the cost of adjustment of capital has been constrained to zero. In a dynamic situation, however, the desired capital stock will not equal (and will generally exceed) the actual stock. The actual output level, Q, which is constrained by the actual capital stock, will generally fall short of the long-run optimal output level. Gould [9] has shown that the use of actual output in determining optimal capital when output is constrained by the nonequilibrium stock of capital K will lead to a bias in the estimation of the long-run value of K*. This occurs if the level of output which can be produced under the constraint imposed by the production function is less than that which the firm would wish to produce given the demand for its product. It is therefore necessary to formulate long-run desired capital in terms of variables which are not influenced by the capital investment decision and the adjustment processes of the firm.[6] To obtain the necessary reduced form model, it will be assumed that a monopolist firm faces the following demand function.[7]

$$(10) \qquad P = \lambda_0 Q^{\gamma_1} Y^{\gamma_2} \qquad \gamma_2 \geq 0 \ , \ \gamma_1 < 0 \ .$$

The shift variable Y is real GNP, and $\gamma_1 = (1/\eta)$, where η is the firm's price elasticity of demand.[8] For the nonmonopolist industry, η is the elasticity of demand for the industry as a whole.

Using the equilibrium values of capital and labor, as given by (6), (7), (8), the demand function (10), the production function (5), and the first order conditions, it can be shown that the desired capital

[6]Gould and Waud [6] have found that this consideration, to some a seemingly theoretical nuance, appears to be an important consideration when estimating investment functions from real-world data, and then using the estimated investment functions to forecast future levels of investment expenditures.

[7]This procedure also eliminates another source of endogeneity present in the desired capital stock specification of (6), i.e., the price-quantity relationship implicit in the demand function. It is assumed that the firms in the industry make a decision with respect to either quantity or price. In this study the firm is presumed to be a price taker and a quantity adjuster. In either case, quantity and price cannot both be considered exogenous to the firm, or the industry.

[8]This follows Gould and Waud [6].

stock can be expressed as a function of technological change, the own price of capital, the costs of labor, and the shift variable, real GNP:[9]

$$(11) \quad K^* = \lambda_o e^{\lambda_1 t} c^{\lambda_2} s_1^{\lambda_3} s_2^{\lambda_4} Y^{\lambda_5}$$

or in log-linear form

$$(12) \quad \ln K^* = \ln\lambda_o + \lambda_1 t + \lambda_2 \ln c + \lambda_3 \ln s_1 + \lambda_4 \ln s_2 + \lambda_5 \ln Y \ .$$

Equation (12) expresses the capital demand function for a monopolist firm. Gould [7] has shown that the model can be extended to the analysis of any industry organization without any change in the interpretation of the demand elasticities λ_i. The only change in the model occurs in the constant term.[10]

Analysis of the raw data showed very high correlations between s_1 and s_2. It is therefore assumed for all industries that $s_2 = \theta s_1$ [11]. In order to avoid serious multicollinearity problems this relationship is used to substitute s_2 out of the derivation which leads to the reduced form (11) and (12). The reduced form model can then be rewritten as

$$(13) \quad \ln K_t^* = \ln\lambda_o + \lambda_1 t + \lambda_2 \ln c_t^* + \lambda_3 \ln s_{1t}^* + \lambda_4 \ln Y_t^*$$

where the coefficient on $\ln Y_t^*$ is now called λ_4 instead of λ_5. The asterisks on c, s, and Y indicate that these are the values expected to hold in the "long run," the permanent values of c, s, and Y; we shall discuss this at greater length below.

[9]The rather lengthy and involved details of this derivation will be provided on request of the authors.

[10]Gould [7, pp. 35, 36] demonstrates that "... these coefficients [λ_i] are the elasticities of K* with respect to each of these variables and hence this result can be interpreted as meaning that a change in the price of productive factors, a shift in demand, or a neutral technological change will have the same proportionate effect on the demand for capital irrespective of whether the industry is monopolistic or competitive in structure. This identity of coefficients has empirical advantages, since the interpretation of the estimated parameters (except the intercept) stays the same even if the organization of the industry is ambiguous."

[11]Simple regression of $\ln s_2 = \ln_\theta + \ln s_1$ produced R_2's of more than .90 for all industries except SIC 34, in which the R_2 was quite small. To maintain uniformity in the results, the assumption $s_1 = \theta s_2$ was also made in SIC 34, although the possibility of specification bias is thereby introduced.

Cost of Adjustment

The desired capital stock K^* appearing on the left side of (13) refers to the amount of capital which is desired at the present time t given the values on the right side of (13). This model, however, like almost all others which have been used in the empirical analysis of investment behavior,[12] has been derived on the assumption that the unit cost of capital goods is invariant with respect to the rate of capital formation. This assumption is no doubt an inaccurate characterization of the capital stock adjustment process since clearly the more rapidly a firm, or industry, tries to purchase and put capital stock in place, the more expensive each unit of capital will become.

The firm's cost of capital adjustment reflects both internal and external cost factors. An internal cost is associated with the introduction of new equipment to a firm's production process. One example of such a cost might be the overtime payments required for the installation of capital equipment in a relatively short period of time. The more rapid the rate of installation for a given unit of capital, the greater these internal costs. The external cost is the purchase price of a unit of capital. For a single firm in a competitive market for capital equipment, external costs of adjustment may well be zero. However, if the firm's desire to accumulate capital more rapidly is held in common with other firms in the market, their common attempt will tend to raise the supply price of capital. For an industry as a whole, regardless of the market structure of the capital goods producing industry, an attempt to increase the rate of capital investment would tend to push up the purchase price of capital.[13] Taking both factors into consideration, a realistic cost of investment function for a manufacturing industry should reflect these nonzero costs of adjustment. Hence it is inconsistent to speak of profit maximizing behavior without recognizing that the rate of investment will be a determinant of the unit cost of capital, and this cost will have an effect upon the profits of the firm. But if costs of investment affect profits, they also affect the desired capital stock variable. That is, the desired capital stock and the rate of investment are determined simultaneously, with the cost of adjustment a factor in their mutual determination.[14]

[12] See Jorgenson [14] for an extensive survey.

[13] For a detailed discussion of adjustment cost function characteristics, see Eisner and Strotz [5].

[14] See Gould [8] for an extensive discussion of these issues.

When it is assumed that the unit cost of capital goods is invariant with respect to the rate of capital formation, the first order conditions for maximization of the present value of all future net cash flows, i.e., maximization of equation (4), do not yield an investment equation but rather the equilibrium value of the capital stock since investment is either zero or infinite, as Haavelmo [10] has demonstrated. This is precisely what is given by the reduced form, equation (13). The typical investment study, having arrived at some expression for K* by a maximization procedure under the assumption that the unit cost of capital goods is invariant with respect to the rate of capital formation, then attempts to relax this assumption and give explicit recognition to the real world fact that firms cannot adjust their actual capital stock to the desired level instantaneously without incurring exorbitantly prohibitive costs of adjustment. They do this by substituting for K* the equation defining K*, such as (13), into some kind of ad hoc adjustment scheme which defines how the actual capital stock is adjusted through time to the desired level K*. Such a scheme is then shown to give rise to an expression defining investment expenditure as a distributed lag function of all the variables defining the desired capital stock.[15]

The only theoretically correct way of dealing with the cost of adjustment problem is to directly incorporate cost of adjustment functions, for both labor and capital, into the objective function, such as (4), and then carry out the maximization procedure.[16] This explicitly recognizes that fact that the rational firm must take explicit account of adjustment costs in the profit-maximizing process. When such costs are included in the objective function, the resulting first order conditions yield the optimum capital stock and the corresponding investment path for the firm. However, the investment functions are nonlinear forms not amenable to linear estimation techniques, and this limits their usefulness in empirical analysis. This is the main reason such a procedure was not followed in this study.

Given that (13) was derived on the assumption that the unit cost of capital is invariant with respect to the rate of capital formation, and given that we know that the unit cost of capital typically rises

[15] For a more complete description of this procedure and a survey of the studies which adopt it, see Jorgenson [14].

[16] See Gould [8] for an extensive discussion of this procedure and the issue in general.

with the rate of capital formation – contrary to assumption, it must be recognized that at any point in time t the desired capital stock K* defined by (13) is not likely to be equal to the actual capital stock K in place at t in a world continually adjusting to change. Only in some long run, static, steady state might we expect K* to equal K.[17] Recognizing therefore the need for characterizing the process by which the actual capital stock K is adjusted to the desired capital stock K* through time, we could adopt the rather general, though ad hoc, adjustment process specified by Jorgenson [15]. Substituting K* as defined by (13) into that scheme gives rise to a distributed lag investment function.[18] Unfortunately, the function is nonlinear and must be estimated by nonlinear estimation techniques. One of the main requirements of this study is to be able to make statements regarding the statistical significance of the estimated relationships between K* and the explanatory variables on the right-hand side of (13). Unfortunately, the theory of statistical inference for nonlinear estimators is not as yet sufficiently developed to allow us to do this. Another serious drawback of the Jorgenson scheme is that it would constrain us to the assumption that the distributed lags on the independent variables in (13) are all of the same length. We have no *a priori* reason for believing this to be the case.

Given all of these considerations the approach taken in this study is to construct ex post measures of the desired capital stock K* for each industry and substitute these measures for K* into (13). Then we may use linear estimation techniques and, in addition, we are not constrained to assume that the independent variables in (13) all have the same distributed lag lengths.

Measuring the Desired Capital Stock

Given that the costs of capital stock adjustment rise with the rate at which the firm adjusts its actual capital stock to its desired or target level, it follows that at any point in time t the firm envisions

[17]Even this would only be approximately true because, in a real world characterized by nonzero adjustment costs, the desired long-run steady state level of the capital stock would be lower than that desired in a world where adjustment costs are zero. This is because nonzero adjustment costs would make any amount of capital more expensive than would be the case if adjustment costs were zero, and these costs would effectively drive up the implicit rental rate on capital thereby reducing the size of the desired capital stock below what it would be if adjustment costs were zero and the implicit rental rate of capital were therefore lower. Hence, even in a long run steady state, K^* as defined by (13) would tend to overstate the amount of capital desired in a world characterized by nonzero costs of adjusting to that steady state.

[18]This has in fact been done elsewhere: see Gould and Waud [6].

making this adjustment to its notion of the desired level, held at time t, over several periods n. Presumably, the more (less) rapidly costs of adjustment rise with the speed of adjustment the lower (larger) will be the rate of adjustment of the actual capital stock to the desired level. It is maintained that the firm's plans for capital accumulation are embodied in its capital appropriation decisions. Given the firm's actual stock of capital in period t and the stock of capital which it desires to have in place in period t+n assuming its anticipations are realized, it is assumed that the firm adjusts its capital appropriations backlog so that the backlog represents the amount of capital expenditures necessary to bring the actual capital stock up to the desired level in period t+n.[19] These expenditures will include replacement investment necessary to maintain the current capital stock plus expenditures for replacement of any net capital formation which occurs over the n periods. Let ϕ_t be that proportion of the appropriation backlog B_t which the firm anticipates will be directed toward net capital formation. Assuming that the firm forecasts its expenditure pattern accurately over the n period horizon, ϕ_t can be estimated ex post, as described below. Subsequently, it can be shown that the desired capital stock for period t+n, as of period t, can be expressed as the sum of current capital stock depreciated at the rate δ over the subsequent n periods, and the depreciated gross investment stream over the same period. We will now develop this notion of the desired capital stock more explicitly.

The concept of desired capital stock employed in this study assumes that in period t, the capital stock desired for period t+n, K^*_t, is equal to the current stock of net depreciable capital assets plus some proportion of the current backlog:

$$(14) \qquad K^*_t = K_t + \phi_t B_t \ .$$

K_t is the stock of net depreciable assets at the end of period t, B_t is the backlog, in real terms, at the end of period t, and ϕ_t is the proportion of the current backlog planned for net capital formation over the investment "horizon" (which is discussed below). The

[19]This notion of the desired capital stock is based on an assumption made by Jorgenson [17, p. 177]. "...We assume that the desired level of capital is equal to the actual level of capital plus the backlog of incompleted investment projects."

remaining proportion of the backlog, $(1 - \phi_t)$, is planned either for maintaining the existing stock of capital over the n period horizon, or for maintaining the new capital stock which is put in place in periods t+1 through t+n−1.

The proportion ϕ_t of the backlog intended for net capital expansion over the horizon is estimated ex post. Net capital expansion over n periods is the sum of depreciated (determination of δ, the depreciation rate, is described below) gross investment over the n periods less the depreciation over n periods of the capital stock in place at the beginning of the n periods (end of period t). Thus:

$$(15) \qquad \phi_t = \frac{\sum_{i=1}^{n} (1-\delta)^{n-i} I_{t+i} - [K_t - K_t(1-\delta)^n]}{B_t}$$

Examination of (15) reveals that it defines the proportion of the backlog intended for net capital expansion over the horizon. Since $K_t(1 - \delta)^n$ represents the amount of capital K_t presently in place which will still be in existence in period t+n, $K_t - K_t(1 - \delta)^n$ represents the amount of capital presently in place which will no longer be in existence in period t + n ; $\sum_{i=1}^{n} (1 - \delta)^{n-i} I_{t+i}$ represents that part of gross investment taking place between t and t+n which will still be in existence as capital stock in period t+n. Hence the numerator of (15) represents the net addition or growth of the capital stock between t and t+n. The numerator of (15) divided by B_t, the total backlog in existence in period t, gives ϕ_t, the proportion of the backlog intended for net capital expansion over the horizon n. The resulting desired capital stock can be expressed as:

$$\begin{aligned}(16) \qquad K_t^* &= K_t + \phi_t B_t \\ &= K_t + \sum_{i=1}^{n} (1-\delta)^{n-i} I_{t+i} - [K_t - K_t(1-\delta)^n] \\ &= \sum_{i=1}^{n} (1-\delta)^{n-i} I_{t+i} + K_t(1-\delta)^n .\end{aligned}$$

The assumption of perfect forecasting is made for the simple reason that the true desired capital stock variable is an ex ante variable which is a function of the expected investment stream over time. Such a simplifying assumption is necessary to allow any estimation whatsoever of desired capital stock. Perhaps the strongest justification for this assumption is provided by the rational expectations hypothesis due to Muth [19]. Basically, that hypothesis asserts that rational economic actors will use forecasting schemes which have the property that they are correct on average, i.e., that they are unbiased predictors. Unfortunately, even if this is true on average, it is still possible of course for the forecaster to be systematically wrong over some finite number of periods. For example, suppose the actual investment stream through period t+n in fact exceeds the planned investment stream based upon conditions in period t. Given the conditions in period t, the firm may accurately forecast what the investment path would be over n periods, were nothing to change after period t. Only if the firm were also accurate in its anticipation of the future values of the explanatory variables in (13) would actual investment over n periods tend to coincide with the expected n period stream from period t to t+n. If however, the economic series under consideration were subject to some exogenous shift introducing a positive time trend for example, it is possible that over time the firm would be revising its desired capital stock upward. This would mean that in period t+i, $0<i\leq n$, the actual rate of investment would include a component resulting from changes in desired capital after period t. If I^*_{t+i} is the expected investment expenditure due to conditions in period t, and if the desired capital stock is revised upward after period t and before t+i, then it is possible that $I_{t+i}>I^*_{t+i}$. Such a situation would introduce a systematic error into measurement of the dependent variable K^*_t, which might give rise to serial correlation.

The planning horizon of the firm is the number of periods n over which the current appropriations backlog is expected to be translated into actual capital formation. The procedure to be used in the estimation of the length of the horizon is that suggested in the NICB Survey of Capital Appropriations.[20] The backlog rate is the ratio of the backlog of capital appropriations outstanding at the end of each quarter, divided by the amount of actual capital expenditures during that quarter. The backlog rate indicates the number of quarters over which the current backlog would be worked off, were it to be spent at the current rate of investment. The high, low and average length of the planning horizon over the period 1954 to 1967 is given for each industry in Table 2. The horizon was computed by taking the rounded value of the backlog rate for each quarter from 1953 to 1967.

The procedure used to estimate the rate of depreciation δ for each industry is that developed by Jorgenson [16, pp. 38-40]. The estimates of the depreciation rates for each industry are shown in Table 3. A description of all the data used in calculating the desired capital stock series for each industry is given in the appendix.

[20]See Cohen [4, p.318].

TABLE 2

LENGTH OF PLANNING HORIZON*

SIC No.	High	Low	Mean
20	4	1	2
22	9	2	5
26	7	3	4
28	7	3	4
29	5	1	3
30	6	1	4
32	8	2	4
33	9	3	6
34	10	3	6
35	6	1	3
36	9	3	5
38	5	1	3

*Rounded.

Source: Computed from NICB Survey on Capital Appropriations.

TABLE 3

ESTIMATED RATE OF DEPRECIATION

SIC #	δ
20	.01235
22	.02015
26	.01302
28	.01942
29	.01316
30	.01839
32	.02051
33	.01919
34	.02079
35	.03123
36	.01165
38	.01067

Expectations and Distributed Lags

In a world of perfect knowledge and positive costs of adjustment, K^*_t would be the capital stock which, given the future paths of the explanatory variables c, s, and Y as of period t, the firm desires for period t+n. This capital stock would in fact be realized in period t+n. But knowledge of the future is not certain, and future values of the explanatory variables will not be known with certainty. As it stands, the formulation of desired capital depends upon variables unknown at time t. To characterize the way the firm handles this problem we assume that the decision maker in the firm has an "anticipation" function. This function transforms ex post data into ex ante data which in this case are the expected, long-run equilibrium values of c, s, and Y prevailing over some specified period of time.[21] These expected long-run, or "permanent," values c*, s*, and Y*, at time t are each assumed to be functions of their past values.[22] The permanent value is incorporated in the form of a distributed lag function of each of the independent variables in (13). (The asterisks indicate these long-run or permanent values of the variables.) The permanent values of the three independent variables are assumed to be exponential functions of past values of each of the respective variables. These anticipation functions can be expressed in log linear form as:

$$\text{(17)} \qquad \ln c_t^* = \sum_{i=0}^{\theta_2} a_{2i} \ln c_{t-i}$$

$$\text{(18)} \qquad \ln s_{1t}^* = \sum_{i=0}^{\theta_3} a_{3i} \ln s_{1t-i}$$

$$\text{(19)} \qquad \ln Y_t^* = \sum_{i=0}^{\theta_4} a_{4i} \ln Y_{t-i}$$

where θ_2, θ_3, and θ_4 are the respective lag lengths on c, s, and Y. Substituting (17), (18), and (19) into (13), the final form of the reduced form model to be estimated is:

[21]The entire future path of the independent variables will not in general be needed for purposes of optimum decision making. Beyond some future date, values of the independent variables will become irrelevant to the current optimum decision. See Modigliani and Cohen [18, pp. 34-36].

[22]Alternatively, the anticipation functions could be interpreted as expressing a relationship between past values of the variables and the relevant future paths of P, s, and c.

$$\text{(20)} \quad \ln K_t^* = \ln \lambda_o + \lambda_1 t + \lambda_2 \sum_{i=0}^{\theta_2} a_{2i} \ln c_{t-i} + \lambda_3 \sum_{i=0}^{\theta_3} a_{3i} \ln s_{1t-i} + \lambda_4 \sum_{i=0}^{\theta_4} a_{4i} \ln Y_{t-i} + u_t$$

where u_t is a disturbance term.

Long-run equilibrium is defined to occur when the permanent values of the variables do not change over their respective anticipation formation periods.[23] This equilibrium condition implies that:

$$\text{(21)} \quad \sum_{i=0}^{\theta_j} a_{ji} = 1 \qquad (j = 2, 3, 4)$$

The sum of the coefficients for each of the three variables estimated will thus be equal to the long-run elasticities λ_2, λ_3, and λ_4. The signs which can be associated with λ_1, λ_3, and λ_4 cannot be established unambiguously on *a priori* grounds.[24] The sign of λ_2, the elasticity of the desired capital stock with respect to the own price or implicit rental rate of capital, can be said *a priori* to be unambiguously negative.

III. Estimation of the Model

Sample Period and Level of Aggregation

The analysis is based upon quarterly data covering the period 1954I to 1967IV. The level of aggregation was dictated by the source of the data on capital backlogs: the National Industrial Conference Board's (NICB) *Quarterly Survey of Capital Appropriations: Historical Statistics, 1953-1967* [1970]. The NICB's survey universe consists of the 1,000 largest manufacturing corporations in terms of total assets. These 1,000 firms are broken down into 15 sub-universes corresponding to 15 industrial categories established by the Standard Industrial Classification (SIC). Capital backlog estimates for the sub-universes are obtained through a sample drawn from each of these 15

[23] This approach to the anticipation function is discussed in detail by Tinsley [23].

[24] For an extensive theoretical discussion of the *a priori* statements which can be made about the signs of λ_1, λ_2, λ_3, and λ_4 in models of this type see Gould [7].

sub-universes. This study examines the demand for capital in 12 of these 15 sub-universes.[25] The 12 industries included in the study are listed in Table 1.

It is presumed that the demand for capital in the sub-universe under consideration is representative of the demand for capital in each of the corresponding industries as a whole. This assertion is made on the basis of the ratios of sub-universe total assets to industry total assets. Except for the textile industry, SIC 22, and the fabricated metal industry, SIC 34, the sub-universe firms hold more than half of the assets in each of the corresponding industries as a whole. These ratios for the years 1954, 1957, and 1967 are given in Table 4.[26]

TABLE 4

PERCENTAGE OF TOTAL INDUSTRY ASSETS HELD BY FIRMS IN NICB SUB-UNIVERSE 1954, 1957, 1967*

SIC No.	1954	1957	1967
20	62.3	57.2	66.4
22	34.6	41.7	58.8
26	55.9	67.5	76.1
28	81.7	80.3	86.2
29	100.0	100.0	95.5
30	84.4	82.2	72.4
32	63.9	66.1	73.4
33	83.7	87.0	85.0
34	43.2	45.9	46.3
35	59.4	56.4	79.2
36	87.7	80.9	79.5
38	62.8	83.5	77.4

*Figures are for the 4th quarter in each year.

Source: *Quarterly Financial Reports for U.S. Manufacturing Corporations; Quarterly Survey of Capital Appropriations.*

[25]Four of the industries are actually three-digit industries. Primary Iron and Steel and Primary Non-Ferrous Metals are combined to obtain SIC 33, Primary Metals. The other two, Transportation Equipment and Motor Vehicles and Equipment form SIC 37, Transportation and Equipment. Because of the 1957 changes in the Standard Industrial Classification cited by Waud [24, p. 424], SIC 37 is omitted from the analysis.

[26]A more complete description of capital backlogs and the NICB Survey can be found in Cohen [4].

While the sample period for the dependent variable, the desired capital stock, covered the 56 quarters from 1954I through 1967IV, the time series for the independent variables were extended further back to reduce the degrees of freedom lost in estimating the distributed lags. Labor costs and real GNP were constructed for the period 1951I through 1967IV. The own price of capital variable could only be extended back through 1952I. Wherever the own price of capital variable was lagged more than 8 quarters, the sample period for the dependent variable was accordingly reduced. The data and sources are described in the appendix.

Multicollinearity and Estimation of the Distributed Lags

When two or more explanatory variables are highly correlated, it is often very difficult to distinguish the separate effects of these variables on the dependent variable. In the presence of such multicollinearity, estimation of the regression coefficients by ordinary least squares will still yield unbiased estimates, but relatively large sampling variances of these coefficients may be obtained, thus potentially understating the actual significance of the explanatory variables implied by the theory. Because of the distributed lag formulation of the model to be estimated here, the reduced form (20), there are a large number of highly intercorrelated explanatory variables which give rise to rather severe multicollinearity. In an attempt to increase the efficiency of our estimation of (20) in the face of this problem, we resorted to the Almon lag procedure [1].

The Almon technique allows indirect estimation of distributed lag weights by a procedure which yields more efficient estimators than direct ordinary least squares (OLS) estimation. Discussing lagged variables, Almon points out that for long lags, "... or when successive observations are too collinear for this straightforward (OLS) treatment, as will frequently be the case with quarterly data, it becomes necessary to make some reasonable, restrictive assumption about the pattern of the weights" [1, p. 179]. The assumption made is that these weights lie on a polynomial function. Use of the Almon procedure is not a solution to the problem of multicollinearity among lagged variables. However, through indirect OLS estimation, it yields unbiased estimates of the distributed lag coefficients which are more efficient than those obtainable through direct OLS estimation which imposes no *a priori* restrictions upon the shape of the lag distribution. This procedure thus reduces the chance of understating the significance of the estimated coefficients due to multicollinearity.[27]

Autocorrelation

Incorrect specification of functional forms and/or of the variables to be included in the functions to be estimated can give rise to autocorrelation. Systematic measurement errors in the dependent variable can also contribute to autocorrelation. If these errors in specification or measurement give rise to a systematic relationship among the disturbances over time, autocorrelation occurs. The disturbance term becomes a proxy for the effects of these specification errors on the dependent variable. Consequently, a necessary assumption for ordinary least squares estimation is violated. OLS estimation of a model with autocorrelated disturbances will still yield unbiased regression coefficients. In general, however, the OLS estimate of the distrubance variance and the sampling variances of the coefficients will be biased; the direction of these biases is difficult to establish.[28]

In preliminary estimations of the model, the Durbin-Watson coefficient consistently indicated the presence of positively autocorrelated disturbances. Subsequent estimation of the model was therefore based on the assumption that the disturbances were related by a first order regressive scheme of the type:

$$(22) \qquad u_t = \rho u_{t-1} + \epsilon_t \qquad |\rho| < 1$$

The disturbance term ϵ_t is assumed to be identically and independently distributed with zero mean and constant variance. The autoregressive coefficient ρ is estimated and then used to transform all of the variables according to the scheme $x_t = (X_t - \rho X_{t-1})$. Estimation of ρ is carried out using the Cochrane-Orcutt iterative procedure. The initial step is the estimation of the model's parameters by OLS, as if no serial correlation were present. The residuals u_t are computed, and then used to estimate the autoregressive coefficient, ρ_1. The raw data are then transformed by ρ_1, and the

[27] For an extensive discussion of the Almon lag technique and its uses and misuses see Schmidt and Waud [20].

[28] See Theil [21], pp. 254-257.

parameters are estimated again, using the transformed data. The residuals are recomputed, and a second estimate ρ_2, and the procedure continues. In the computer program used for this study, the procedure continues until either:

i) two successive estimates of ρ differ less than .001;
ii) the number of iterations exceeds 20;
iii) ρ exceeds .975, in which case first differences are indicated as necessary.

Generalized least squares (GLS) estimation of the model, using the transformed data, will yield unbiased estimates of the disturbance variance if ρ is correctly estimated; unbiased estimates of the sampling variances of the regression coefficients will also be obtained. However, the Cochrane-Orcutt procedure yields a local minimum for the sum of the square of transformed residuals, which is not necessarily the global minimum. However, even if ρ is incorrectly estimated, GLS estimation will generally reduce the bias in OLS estimation of the disturbance variance as well as the biases in the sampling variances of the regression coefficients.[29]

Minimum Standard Error Criterion and Selection of Lag Lengths

The choice of an appropriate specification of the lengths of the distributed lags on each of the independent variables in (20) is a complex decision problem for which no formal statistical procedure is available. However, in regression problems with fixed independent variables, such as ours, Theil [22, p. 211-215] has suggested a justification for the criterion of minimizing the estimated standard error of regression. This is the criterion used in this study. There is no reason to suppose that this criterion will be satisfied when ln c, ln s, and ln Y all have the same lag length. Certainly a much more general search is necessary to allow for the sizable probability that the lag lengths on ln c, ln s, and ln Y which satisfy the minimum standard error criterion are all different. For each industry studied here, searching over *all possible* lag combinations on ln c, ln s, and ln Y for as many as up to 12 periods in some instances, this was found to be the case.

[29] See Theil [21] p. 256.

When searching the lag space beyond four quarters the Almon technique is used; a fourth degree polynomial is assumed and no endpoint constraints are imposed. Of course in the case of a fourth degree polynomial, any lag length less than or equal to four periods is simply estimated by ordinary least squares. Imposing endpoint constraints by constraining the weights at these points to be zero is not warranted unless it can be established that such constraints are valid. In the absence of validation, no such constraints should be imposed – otherwise there will be misspecification errors. Using the Almon technique without imposing endpoint constraints allows the data to tell whether such constraints are valid.[30]

Estimation Results

Searching all possible lag lengths on ln s, ln c, and ln Y in each industry up through three years, the estimates of the reduced form (20) which give the minimum standard error of regression are reported in Tables 5 through 16. In each industry the lag space was always searched through 12 quarters including the current quarter. This required examination of approximately 500 equations in each industry. In several industries the minimum standard error of regression occurred when one of the independent variables had a lag length of 11 quarters. This means it is possible that the lag lengths in those cases on those variables may be longer. Nonetheless this was quite an exhaustive search procedure and indicates that further search might reveal an even longer lag length in these instances. As discussed above, since the disturbance terms always seemed to be autocorrelated, we used generalized least squares (GLS) and estimated the autoregression coefficient ρ by the Cochrane-Orcutt procedure. Since the reduced form (20) is expressed in logarithms, the regression coefficients may be interpreted as elasticities.[31]

[30] For a more extensive discussion of the use of the Almon technique see Schmidt and Waud [20].

[31] In the presence of autocorrelated disturbances the minimum standard error criterion is only justified asymptotically.

TABLE 5

SIC 20

GLS REGRESSION ESTIMATES OF EQUATION (20)*

(t-statistics)

Period	s	c	Y
t	0.1331 (0.2251)	0.0057 (0.0938)	−0.1966 (1.4144)
t-1	−0.2415 (0.4031)	−0.0165 (0.2675)	0.0235 (0.1633)
t-2	−0.4023 (0.6491)	−0.0491 (0.7481)	0.0644 (0.4900)
t-3	−0.2854 (0.5035)	−0.0712 (1.1636)	0.0997 (0.7220)
t-4	−0.8149 (1.2585)	0.0582 (0.9997)	0.1855 (1.4143)
t-5			0.2607 (1.9512)
t-6			0.1465 (1.3118)
Σ	−1.6109 (2.1361)	−0.0729 (0.5531)	0.5838 (1.1845)
λ_1	0.0219 (1.9731)		
Cons.	6.1010 (2.4826)		
$\bar{R}^2$	0.9911		
SE	0.0142		
DW	1.7755		
ρ	0.8643		

*Data transformed into logarithms. Coefficients estimated using Almon lags. $\bar{R}^2$ is R^2 adjusted for degrees of freedom. SE is the standard error of regression. DW is the Durbin-Watson statistic. ρ is the autoregression coefficient on the disturbance terms estimated by the iterative Cochrane-Orcutt procedure.

TABLE 6

SIC 22

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	0.4635 (0.9704)	−0.2469 (2.4216)	0.5424 (2.1774)
t-1	−0.1287 (0.2697)	−0.0893 (1.4128)	0.0274 (0.1017)
t-2	0.7766 (1.7230)	−0.0495 (0.6998)	−0.1408 (0.5544)
t-3	0.0141 (0.0301)	−0.0729 (1.1334)	0.0166 (0.0645)
t-4	0.5399 (1.0689)	−0.1176 (2.1593)	−0.4566 (1.7153)
t-5		−0.1541 (3.0412)	
t-6		−0.1654 (3.4302)	
t-7		−0.1470 (3.5159)	
t-8		−0.1070 (2.9467)	
t-9		−0.0657 (1.7678)	
t-10		−0.0562 (1.6240)	
t-11		−0.1239 (2.1790)	
Σ	1.6054 (1.5812)	−1.3954 (3.1385)	−0.0111 (0.0107)
λ_1	0.0112 (0.6386)		
Cons.	2.9224 (0.7119)		
$\bar{R}^2$	0.9837		
SE	0.0193		
DW	2.0051		
ρ	0.9415		

+See * Table 5.

TABLE 7

SIC 26

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	0.6169 (1.8269)	0.0521 (0.7413)	–0.0657 (0.7171)
t-1	0.4754 (0.5879)	–0.0509 (1.9216)	–0.1214 (0.7936)
t-2	–0.0750 (0.0888)	–0.0672 (1.7887)	0.0105 (0.0912)
t-3	–0.6126 (1.2229)	–0.0421 (1.6081)	0.1659 (2.6378)
t-4	–0.8628 (2.2814)	–0.0084 (0.3727)	0.2447 (2.2663)
t-5	–0.6951 (1.2153)	0.0132 (0.4315)	0.2100 (1.8067)
t-6	–0.1238 (0.2087)	0.0142 (0.4738)	0.0888 (1.1467)
t-7	0.6928 (1.5683)	–0.0014 (0.0576)	–0.0287 (0.2878)
t-8	1.4517 (2.7290)	–0.0175 (0.6954)	0.1115 (0.0368)
t-9	1.7058 (2.0463)	–0.0058 (0.2384)	0.4270 (4.3313)
t-10	0.8634 (1.0982)	0.0074 (1.5250)	
t-11	–1.8115 (4.3904)		
Σ	1.6280 (0.8468)	–0.0393 (0.2947)	0.9426 (3.4824)
λ_1	0.0094 (2.0040)		
Cons.	3.8518 (2.5858)		
$\bar{R}^2$	0.9926		
SE	0.0149		
DW	1.8393		
ρ	0.0451		

+See * Table 5.

TABLE 8

SIC 28

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	–0.6222 (0.7310)	–0.1923 (2.8054)	–0.0955 (0.7172)
t-1	–0.7942 (1.0469)	–0.0186 (0.3343)	–0.0135 (0.0674)
t-2	0.7091 (0.9365)	–0.0839 (1.7822)	0.1032 (0.5804)
t-3	0.0488 (0.0641)	–0.1671 (2.8179)	0.2246 (1.6052)
t-4	–0.4905 (0.5158)	–0.1680 (3.2353)	0.3282 (2.2755)
t-5		–0.1079 (1.8215)	0.3984 (2.8063)
t-6		–0.1289 (2.0959)	0.4270 (3.5626)
t-7			0.4128 (3.1282)
t-8			0.3620 (2.4457)
t-9			0.2877 (2.8036)
Σ	–1.1490 (0.8622)	–0.8666 (4.2454)	2.4349 (3.2134)
λ_1	0.0012 (0.0631)		
Cons.	–2.9072 (0.7269)		
$\bar{R}^2$	0.9936		
SE	0.0158		
DW	2.2359		
ρ	0.8596		

+See * Table 5.

TABLE 9

SIC 29

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	0.2147 (0.8458)	−0.0801 (1.7007)	0.2996 (3.1536)
t-1	−0.2289 (0.7201)	−0.0253 (0.5952)	0.5038 (4.9658)
t-2	−0.2029 (0.6020)	0.0552 (1.4051)	0.2726 (2.7521)
t-3	0.0343 (0.1485)	0.0312 (0.8134)	−0.0208 (0.1832)
t-4	0.2895 (1.5099)	−0.0755 (1.7198)	−0.1569 (1.2475)
t-5	0.4351 (1.8044)	−0.0919 (2.3034)	−0.0703 (0.5488)
t-6	0.4089 (1.6989)		0.1504 (1.1820)
t-7	0.2145 (1.1384)		0.2625 (2.5268)
t-8	−0.0795 (0.3537)		
t-9	−0.3386 (1.0151)		
t-10	−0.3630 (1.1319)		
t-11	0.1126 (0.4560)		
Σ	0.4967 (0.4120)	−0.1863 (1.5612)	1.2409 (2.9135)
λ_1	−0.0089 (1.3196)		
Cons.	3.3491 (1.4136)		
$\bar{R}^2$	0.9912		
SE	0.0115		
DW	2.1189		
ρ	0.5835		

+See * Table 5.

TABLE 10

SIC 30

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	−0.0635 (0.1446)	−0.5584 (6.0047)	−0.4750 (2.9728)
t-1	1.4487 (2.6254)	−0.0733 (2.6164)	0.6572 (4.5781)
t-2	−0.1138 (0.1918)	0.0877 (2.9520)	1.0075 (6.5983)
t-3	0.2160 (0.3745)	0.0709 (2.9772)	0.8677 (7.4683)
t-4	0.5677 (1.0265)	−0.0121 (0.6143)	0.4947 (5.1478)
t-5		−0.0838 (3.0207)	0.1101 (1.2078)
t-6		−0.1006 (3.1780)	−0.0998 (1.0954)
t-7		−0.0537 (2.0054)	0.0161 (0.1459)
t-8		0.0320 (1.5144)	0.5736 (3.2152)
t-9		0.0970 (3.9290)	
t-10		0.0477 (2.0036)	
t-11		−0.2435 (5.5705)	
Σ	2.0552 (4.1924)	−0.7902 (3.7237)	3.1520 (8.2358)
λ_1	−0.0331 (4.2092)		
Cons.	−9.7346 (4.2700)		
$\bar{R}^2$	0.9915		
SE	0.0192		
DW	2.1346		
ρ	−0.4694		

+See * Table 5.

TABLE 11

SIC 32

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	0.6221 (0.8174)	−0.0380 (0.4615)	0.2235 (1.3778)
t-1	−0.3209 (0.5160)	0.0355 (0.8532)	0.4641 (2.7579)
t-2	−0.2075 (0.2942)	0.0459 (1.0062)	0.3419 (2.2475)
t-3	−0.8430 (1.2360)	0.0026 (0.6636)	0.0965 (0.6514)
t-4	−0.9194 (1.3047)	−0.0120 (0.4039)	−0.1040 (0.7363)
t-5		−0.0426 (1.2753)	−0.1634 (1.3295)
t-6		−0.0613 (2.0709)	−0.0569 (0.4306)
t-7		−0.0672 (2.7718)	0.1686 (1.0787)
t-8		−0.0669 (2.0868)	
t-9		−0.0739 (2.2733)	
t-10		−0.1092 (2.0770)	
Σ	−1.6687 (3.0849)	−0.3671 (2.0987)	0.9704 (2.8429)
λ_1	0.0134 (1.7794)		
Cons.	3.6093 (1.9246)		
$\bar{R}^2$	0.9820		
SE	0.0193		
DW	1.9177		
ρ	0.1959		

+See * Table 5.

TABLE 12

SIC 33

GLS REGRESSION ESTIMATES OF EQUATION (20)+

(t-statistics)

Period	s	c	Y
t	0.3245 (1.0616)	0.0088 (0.1351)	0.3191 (2.0805)
t-1	0.1520 (0.4763)	0.0348 (0.7775)	0.2585 (1.8708)
t-2	0.2397 (0.7102)	0.0169 (0.3901)	0.2365 (1.6131)
t-3	0.4454 (1.4965)	−0.0014 (0.0340)	0.2881 (1.7673)
t-4	0.6603 (2.1570)	0.0046 (0.1124)	0.4043 (2.0822)
t-5	0.8093 (2.3634)	0.0401 (1.0855)	0.5316 (2.5939)
t-6	0.8504 (2.5213)	0.0916 (2.4901)	0.5727 (2.8635)
t-7	0.7756 (2.7153)	0.1261 (2.5875)	0.3860 (2.1953)
t-8	0.6101 (2.3785)	0.0918 (1.8993)	−0.2144 (1.2341)
t-9	0.4128 (1.4199)	−0.0826 (1.1313)	
t-10	0.2759 (0.9987)		
t-11	0.3254 (1.2466)		
Σ	5.8813 (2.4383)	0.3308 (1.7549)	2.7825 (4.1272)
λ_1	−0.0410 (2.7577)		
Cons.	−4.0628 (1.0743)		
$\bar{R}^2$	0.9690		
SE	0.0156		
DW	2.0088		
ρ	0.6779		

+See * Table 5.

TABLE 13
SIC 34
GLS REGRESSION ESTIMATES OF EQUATION (20)+
(t-statistics)

Period		s	c	Y
t		0.1688 (0.6415)	−0.0321 (0.4649)	0.0821 (0.5913)
t-1		0.4399 (1.1201)	0.0558 (1.5466)	0.3179 (3.0043)
t-2		−0.2180 (0.5298)	0.1055 (2.4767)	0.2496 (2.4061)
t-3		−0.0055 (0.0143)	0.1097 (3.0917)	0.0519 (0.4968)
t-4		−0.1289 (0.5265)	0.0704 (1.9031)	−0.1443 (1.2958)
t-5			−0.0006 (0.0166)	−0.2512 (2.1704)
t-6			−0.0822 (2.1491)	−0.2249 (2.0773)
t-7			−0.1437 (2.9874)	−0.0650 (0.7066)
t-8			−0.1449 (3.0189)	0.1853 (2.1842)
t-9			−0.0360 (0.5319)	0.4395 (4.5987)
t-10				0.5671 (5.4849)
t-11				0.3943 (3.1470)
Σ		0.2563 (1.2214)	−0.0982 (0.6718)	1.6022 (6.4750)
λ_1	−0.0081 (5.6612)			
Cons.	−0.0558 (0.0546)			
$\bar{R}^2$	0.9760			
SE	0.0201			
DW	1.9343			
ρ	−0.1429			

+See * Table 5.

TABLE 14
SIC 35
GLS REGRESSION ESTIMATES OF EQUATION (20)+
(t-statistics)

Period		s	c	Y
t		7.5425 (5.3193)	−0.3871 (3.9435)	−0.3973 (2.4081)
t-1		−1.6001 (0.6122)	0.0878 (1.7673)	−0.3161 (1.6131)
t-2		−2.8669 (1.0334)	0.0919 (1.8100)	−0.0944 (0.6171)
t-3		−0.4595 (0.3011)	−0.0886 (2.9081)	0.2012 (2.3570)
t-4		2.4895 (2.2731)	−0.2535 (6.0529)	0.5117 (4.5142)
t-5		3.9173 (2.1182)	−0.2886 (5.7095)	0.7864 (6.1668)
t-6		2.8303 (1.5440)	−0.1654 (3.3081)	0.9824 (9.6515)
t-7		−0.6952 (0.7187)	0.0583 (0.9667)	1.0648 (8.9190)
t-8		−5.5138 (4.0412)	0.2390 (4.3674)	1.0067 (6.9836)
t-9		−9.4104 (3.4276)	0.1474 (1.6832)	0.7892 (4.9294)
t-10		−9.1104 (3.3112)		
t-11		−0.2299 (0.2118)		
Σ		−13.0966 (1.9365)	−0.5590 (3.0449)	4.5346 (17.9194)
λ_1	− 0.0470 (5.5730)			
Cons.	−15.4342 (9.7946)			
$\bar{R}^2$	0.9932			
SE	0.0238			
DW	1.9163			
ρ	− 0.2756			

+See * Table 5.

TABLE 15
SIC 36
GLS REGRESSION ESTIMATES OF EQUATION (20)+
(t-statistics)

Period	s	c	Y
t	−3.3508 (4.4839)	−0.1102 (1.3411)	−0.7150 (4.9473)
t-1	1.6587 (1.3915)	−0.1748 (3.8035)	−0.4205 (2.3644)
t-2	−1.8384 (1.4352)	−0.1947 (3.9607)	−0.6742 (3.9865)
t-3	−1.3266 (0.9819)	−0.2213 (5.4038)	−1.0630 (6.9237)
t-4	−2.0911 (2.2068)	−0.2801 (6.1361)	−1.3002 (7.5403)
t-5		−0.3701 (7.5684)	−1.2252 (6.5704)
t-6		−0.4644 (9.4806)	−0.8038 (4.8483)
t-7		−0.5097 (8.8559)	−0.1281 (1.0237)
t-8		−0.4267 (7.6627)	0.5837 (5.0857)
t-9		−0.1098 (1.5227)	0.9870 (8.1672)
t-10			0.6180 (4.8934)
Σ	−6.9482 (9.7444)	−2.8616 (10.4534)	−4.1486 (5.9487)
λ_1	0.0997 (9.0103)		
Cons.	24.3705 (7.5357)		
$\bar{R}^2$	0.9872		
SE	0.0270		
DW	1.9605		
ρ	0.1118		

+See * Table 5.

TABLE 16
SIC 38
GLS REGRESSION ESTIMATES OF EQUATION (20)+
(t-statistics)

Period	s	c	Y
t	2.5955 (1.5099)	0.0878 (0.5834)	0.0084 (0.0303)
t-1	2.2404 (1.1913)	−0.0575 (0.3803)	0.3569 (1.3507)
t-2	−3.6129 (1.8400)	−0.2853 (1.8800)	0.4705 (1.8914)
t-3	−1.1552 (0.6104)	0.2339 (1.4455)	0.4423 (2.0677)
t-4	0.1890 (0.1003)	−0.1342 (0.8315)	0.3477 (1.6380)
t-5			0.2441 (1.0376)
t-6			0.1711 (0.7109)
t-7			0.1507 (0.7008)
t-8			0.1868 (1.0462)
t-9			0.2657 (1.5991)
t-10			0.3557 (2.0452)
t-11			0.4074 (1.7139)
Σ	0.2567 (0.1762)	−0.1552 (0.5059)	3.4070 (2.4702)
λ_1	−0.0100 (0.4206)		
Cons.	−9.4545 (1.3484)		
$\bar{R}^2$	0.9878		
SE	0.0368		
DW	2.0340		
ρ	0.6568		

+See * Table 5.

A comparison of the sums (Σ) of the estimated distributed lag regression coefficients associated with ln s, ln c, and ln Y and the t-statistics associated with these sums (Tables 5 through 16) indicates that all three of these variables appear to have a significant influence in SIC 30, 32, 33, 35, and 36 (Tables 10, 11, 12, 14, and 15). It is noteworthy that four of these industries, SIC 32, 33, 35, and 36 are durable goods industries and that all five of these industries are among the most cyclical variable of the 2-digit SIC industries in U. S. manufacturing. As noted above, multicollineraity is a major difficulty in a study of this nature and the problem is more acute in those industries where there is less cyclical variability in the data, such as is the case in the nondurable goods sector of U. S. manufacturing. Since multicollinearity causes the estimated standard errors associated with estimated regression coefficients to "blow-up," i.e. pushes the estimated t-statistics toward zero, the apparent insignificance of many of the sums (Σ) of the estimated distributed lag coefficients of the nondurable goods industries SIC 20, 22, 26, 28, and 29 (Tables 5, 6, 7, 8, and 9) may well be a reflection of this problem and not necessarily an indication of the true influence of these variables in these industries. It is suspected that a major factor contributing to the multicollinearity problem is the presence of the time variable t in these regressions; unfortunately there did not appear to be any other tractable way of controlling for technological change. Experimentation with some of the industries indicated a notable increase in the t-statistics when time was dropped from the regressions.

In 6 of the 12 industries the sum of the estimated regression coefficients associated with s, the hourly cost of a production worker manhour, appears to be significant: SIC 20, 30, 32, 33, 35, and 36 (Tables 5, 10, 11, 12, 14, and 15 respectively). The signs of these sums are negative in four of these industries, SIC 20, 32, 35, and 36 (Tables 5, 11, 14, and 15 respectively) and positive in two, SIC 30 and 33 (Tables 10 and 12 respectively). As was noted above, it is not possible to specify on *a priori* grounds what the sign of the coefficient of hourly labor costs should be. This is because it is not possible to say *a priori* whether substitution effects or scale effects will dominate when there is a change in relative factor prices. When hourly labor cost increases (falls), labor becomes more (less) expensive relative to capital. The substitution effect alone dictates that more (less) capital be used relative to labor. However, the increase (decrease) in the hourly labor cost causes the industry supply schedule to shift up (down) and this causes a reduction (an increase) in industry output which by itself has the scale effect of reducing (inceasing) the use of both inputs. If the demand schedule facing the industry is elastic enough the scale effect causing a reduction (an increase) in the demand for manhours and the demand for capital services, may more than offset the increase (decrease) in the demand for capital services stemming from the substitution effect. The net result is that an increase (a decrease) in hourly labor costs leads to a reduction (an increase) in the demand for capital services as well as in the demand for labor services. Hence, depending on the elasticity of the demand schedule facing the industry, the sign of the regression coefficient associated with the hourly cost of a production worker manhour may be either positive or negative.[32]

The sum of the estimated regression coefficients associated with c, the implicit rental rate or own price of capital, appears significant in 8 out of the 12 industries: SIC 22, 28, 29, 30, 32, 33, 35, and 36 (Tables 6, 8, 9, 10, 11, 12, 14, and 15 respectively). In seven out of these eight the signs of the sums are negative as we would expect on *a priori* grounds. The positive sign in SIC 33 (Table 12), the one exception, is contrary to theoretic considerations. If the own price of capital rises (falls), then the substitution effect dictates that less (more) capital and more (less) labor be used. The scale effect, resulting from the upward (downward) shift in the supply schedule due to the increased (decreased) cost of capital, dictates that less (more) of both inputs be used. Hence, both the substitution and the scale effect operate to reduce (increase) the use of capital in response to a rise (fall) in the own price of capital.

The sizes of the negative sums of the significant estimated regression coefficients associated with c (Tables 6, 8, 9, 10, 11, 14, and 15) are the magnitudes of the elasticities of the desired capital stock in each industry with respect to the own price of capital. Examination of these estimates suggests that a 1 percent fall in c will cause a rise in the desired stock of capital ranging anywhere from about 0.19 percent after five quarters in the case of SIC 29 (Table 9), to as much as 2.86 percent after nine quarters in the case of SIC 36 (Table 14). The lengths of the distributed lags on c in these industries range from a low of 5 quarters in SIC 29 (Table 9) to a high of 11 quarters in

[32] For a more technical discussion see Gould [7].

SIC 22 (Table 6) and SIC 30 (Table 10). Given our lag length search procedure described above, the true maximum lag length in some instances may be even longer. In order to get an estimate of the total distributed lag length from the point in time of the change in c and the point at which the actual investment expenditures have brought the actual capital stock to the desired level in any industry, the mean length of the planning horizon given in Table 2 must be added to the corresponding industry lag length given in one of the Tables 6, 8, 9, 10, 11, 14, and 15. The variability of the lengths of the planning horizons shown in Table 2 should be kept in mind when assessing these lags. These results are summarized in Table 17 for the seven industries having significant negative estimated sums of regression coefficients, or elasticities, associated with c, the own price of capital.

In all industries except SIC 20 and 22 (Tables 5 and 6) the estimated sum of the regression coefficients or elasticities associated with Y, gross national product, appear significant. Among the ten industries for which this sum elasticity appears significant, only one of them has a negative sign – SIC 36 (Table 15), Electrical Machinery and Equipment. While the sign of the sum elasticity associated with Y cannot be specified on *a priori* grounds, since an industry may move cyclically or contracyclically, we are suspicious of the negative sign in SIC 36 simply because it is hard to believe that this industry responds negatively to movements in general economic activity as measured by GNP. For the nine industries with significant positive estimated sum elasticities, a 1 percent change in Y would appear to cause an increase in the desired capital stock ranging anywhere from about 0.94 percent in the case of SIC 26 (Table 7), with a distributed lag of nine quarters, to as high as 4.53 percent in SIC 35 (Table 14), also with a nine quarter distributed lag. The lengths of these distributed lags range from 7 quarters for SIC 29 (Table 9) and SIC 32 (Table 11) up to 11 quarters for SIC 34 (Table 13) and SIC 38 (Table 16). Again, given our description of the lag length search procedure, it is possible in some instances that the true maximum lag length may be longer. The estimated sums of the regression coefficients or elasticities on Y and their distributed lag lengths are summarized in Table 18 for the ten industries where they appear significant. The accelerator-type of effects of changes in GNP on the desired capital stock in each of these industries appears to be quite strong. Again, an estimate of the total length of the distributed lag between a change in GNP and the point at which the actual investment expenditures have brought the actual capital stock to the desired level in any industry requires that the mean length of the planning horizon in Table 2 be added to that shown in Table 18.

Regarding the individual regression coefficients which add up to the sums in Table 5 through 16, there are instances where the signs switch, or "flip-flop," at some point in the distributed lag. It appears that this happens with statistical significance in: SIC 26 (Table 7) in the case of s; SIC 30 (Table 10) in the case of c and Y; SIC 34 (Table 13) in the case of c and Y; SIC 35 (Table 14) in the case of s, c, and Y; and SIC 36 (Table 15) in the case of Y. The significant switching of signs among these distributed lag weights cannot be ruled out as theoretically implausible on *a priori* grounds. Gould [8] has shown in a dynamic theory of investment of the firm that in some instances there is reason to expect the true distributed lag weights to switch sign.[33]

TABLE 17

ESTIMATED DISTRIBUTED LAG LENGTHS BETWEEN CHANGE IN OWN PRICE OF CAPITAL AND TOTAL CHANGE IN DESIRED STOCK OF CAPITAL ΔK^* AND TOTAL CHANGE IN ACTUAL CAPITAL STOCK ΔK FOR SIC 22, 28, 29, 30, 32, 35, 36

Industry	ΔK^* lag length⁺ (1)	$\bar{n}$ Mean Planning Horizon⁼ (variation) (2)	ΔK lag length equal (1)+(2) (3)	Σ Elasticity⁺ (t-statistic) (4)
SIC 22	11	5 (2–9)	16	−1.3954 (3.1385)
SIC 28	6	4 (3–7)	10	−0.8666 (4.2454)
SIC 29	5	3 (1–5)	8	−0.1863 (1.5612)
SIC 30	11	4 (1–6)	15	−0.7902 (3.7237)
SIC 32	10	4 (2–8)	14	−0.3671 (2.0987)
SIC 35	9	3 (1–6)	12	−0.5590 (3.0449)
SIC 36	9	5 (3–9)	14	−2.8616 (10.4534)

⁺From Tables 6, 8, 9, 10, 11, 14 and 15.

⁼From Table 2.

[33] However it is also possible that this phenomenon is an artifact of attempting to estimate distributed lags by use of higher order polynomials. See Schmidt and Waud [20].

In 8 of the 12 industries, SIC 20, 26, 30, 32, 33, 34, 35, and 36 (Tables 5, 7, 10, 11, 12, 13, 14, and 15 respectively), the estimated regression coefficient associated with t, time, appears to be significant. It will be recalled that time was introduced in order to control for technological change. *A priori*, it is not possible to specify what the sign of the coefficient λ_1 on time should be. It is conventional to presume that it should be negative on the assumption that technological progress will diminish the size of the desired stock of capital. This presumption is not necessarily correct however. In an industry facing an elastic demand schedule for its product, it is possible for λ_1 to have a positive sign. A positive λ_1 indicates that firms will increase

TABLE 18

ESTIMATED SUMS OF REGRESSIONS COEFFICIENTS OR ELASTICITIES ON GNP AND THEIR DISTRIBUTED LAG LENGTHS FOR SIC 26, 28, 29, 30, 32, 33, 34, 35, and 36

Industry	GNP Elasticity+ (t-statistic)	Lag length
SIC 26	0.9426 (3.4824)	9
SIC 28	2.4349 (3.2134)	9
SIC 29	1.2409 (2.9135)	7
SIC 30	3.1520 (8.2358)	8
SIC 32	0.9704 (2.8429)	7
SIC 33	2.7825 (4.1272)	8
SIC 34	1.6022 (6.4750)	11
SIC 35	4.5346 (17.9194)	9
SIC 36	−4.1486 (5.9487)	10
SIC 38	3.4070 (2.4702)	11

+From Tables 7-16.

their desired stock of capital in response to technological improvement. If the industry demand schedule is sufficiently elastic, an increase in productivity will cause the industry supply schedule to shift rightward causing a relatively large increase in equilibrium industry output. The increase in productivity by itself, as reflected in normal replacements, would not be sufficient to permit the increased production without an increase in the total stock of capital.[34] In this case λ_1 would have a positive sign. Of the eight industries having significant estimates of λ_1, the sign on λ_1 is positive in four of them: SIC 20, 26, 32, and 36 (Tables 5, 7, 11, and 15).

IV. Implications for a Variable Investment Tax Credit Scheme as a Stabilization Tool

Before drawing any policy implications from the estimates presented here, it should be reemphasized that there are many caveats which dictate reservation and caution in interpreting our results. The model we have used, like others which have characterized empirical research in this area, does not adequately incorporate the dynamic considerations of adjustment cost in its explicit derivation from the profit maximization process. Rather, adjustment costs and expectations formation are tacked on ad hoc by imposing a distributed lag scheme ex post the explicit profit maximization derivation; again, this has been the common practice of other well-known econometric research efforts in this area. Ours is a putty-putty model and assumes a Cobb-Douglas production function. Jorgenson's [14, pp. 1131-1133] survey of the research on the tenability of the Cobb-Douglas assumption concludes that overall this assumption is not inconsistent with the findings of empirical investigations of this issue. However, some might justifiably feel more comfortable if the more general CES specification had been used in this study. Also, there is little doubt but that a putty-clay model is a more accurate characterization of the world than a putty-putty model.

Statistically, multicollinearity was a major problem in the data used here and this may account for the lack of evidence of statistical significance among several of the nondurable goods industries. Perhaps even more worrisome are the many approximations and heroic assumptions which were needed in the process of constructing

[34] This argument is similar to those regarding scale and substitution effects. Again, for a more technical and rigorous treatment of the signs of parameters like λ_1, λ_2, λ_3, and λ_4 in reduced form neoclassical models see Gould [7].

the data – both by us and the various agencies which collect the raw data by sampling procedures. No doubt this gives rise to not insignificant errors in variables problems. These problems are common to any econometric investigation, but when drawing policy implications for the consideration of policy makers and others not often so aware of econometric and statistical nuances it is especially important that they be emphasized. All of these problems aside, there is still the usual imprecision inherent in any interpretation of statistical estimates. With these reservations in mind, the following tentative conclusions are offered.

As indicated at the outset, a VITC scheme would operate by changing the implicit rental rate or own price of capital. Our estimates of the elasticity of the desired capital stock with respect to the own price of capital suggest that the own price of capital is a significant determinant of the desired capital stock level, particularly in the durable goods industries. Hence a VITC scheme would appear to be a potential stabilization policy tool insofar as changes in the own price of capital could be expected to have a significant, and predictable, effect on the desired capital stock and thus on investment expenditures. However our results (summarized in Table 17) suggest that these effects occur with rather lengthy distributed lags, requiring anywhere from 5 to 11 quarters for the full effects of a change in the own price of capital on the desired stock of capital to be realized, and on average another three to five quarters for actual investment expenditures to finally bring the actual level of the capital stock into line with the desired level. In view of our description of the lag length search procedure above, it is possible that in some instances the lag lengths may be even longer. These findings lend support to the suggestion that a VITC scheme be administered in such a way as to encourage the bunching of investment expenditures, as described in Section I above, with the intention of shortening the lag lengths which would otherwise appear to be inordinantly long from a policy-maker's standpoint.

Finally, as was pointed out in Section I, to the extent there are multiplier-accelerator-type feedbacks from investment expenditures to general economic activity (as measured by GNP) and back to investment expenditures, any increase in the stability of investment expenditures brought about by a VITC scheme would, by virtue of this multiplier-accelerator feedback linkage, reduce fluctuations in investment expenditures even more. This itself would make the stabilization task of a VITC scheme easier, once it is properly initiated. Our estimates (summarized in Table 18) suggest that this feedback is significant and quite strong – as proponents of an accelerator theory of investment would predict Again, however, the distributed lag lengths of these effects appear quite long, ranging between 7 and 11 quarters, possibly longer, for the full realization of their impact on the desired capital stock, plus on average another three to five quarters for actual investment expenditures to fully bring the actual level of the capital stock into line with the desired level. Nonetheless, any initial stabilization of investment expenditures and thus GNP, brought about by a VITC scheme, could be expected to receive substantial subsequent reinforcement from the accelerator effects of GNP on investment expenditures – at least according to the estimates we have presented.

The stabilization potential of a VITC scheme depends crucially on yet another factor which has not been a subject of investigation in this study. Namely, the ability of the policymaker, vested with the authority to administer the VITC scheme, to forecast sufficiently well so that his stabilization efforts are appropriately timed. Otherwise, the administration of a VITC scheme will only aggravate the instability it is designed to alleviate. To the extent our estimates suggest that it can be a powerful tool for increasing economic stability, it can also be a destabilizing force in the hands of a policymaker lacking sufficient prescience.

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APPENDIX
SOURCES, DESCRIPTION, AND DERIVATION OF DATA

Capital Stock, Backlogs, and Investment

Net Depreciable Capital Assets. For the period 1952 through 1968, quarterly estimates of net fixed capital assets for two digit manufacturing industries are obtained from the *Quarterly Financial Reports for U.S. Manufacturing Corporations*. The estimates reported are obtained from a sample selected from all U. S. corporations filing a corporate tax return.

The net fixed capital asset data reported are estimates of land plus net depreciable assets plus net depletable assets. In order to get an estimate of the stock of net depreciable assets, it is necessary to first obtain quarterly estimates of the ratio of net depreciables to net fixed capital assets. Annual ratios of net depreciables to net fixed capital assets can be computed directly from the *Statistics of Income: Corporate Income Tax Returns* for the period 1954 to 1967.[1] Net fixed capital stock for each industry is obtained by taking the sum of depreciable assets less accumulated depreciation, depletable assets less accumulated depletion, and land. For the years 1952 and 1953, the fixed capital estimate is not broken down into depletable and depreciable assets; the data is not available for 1968. Thus the ratio of depreciables to total fixed capital cannot be directly computed for these years. Based upon the stable pattern of these ratios over time, it was assumed that the average ratio for the period 1954 to 1967 could be used for the years 1952, 1953, and 1968. The mean, high, and low values of the ratios for each industry are presented in Table A-1. The annual ratios are interpolated linearly to obtain quarterly ratios for each industry. Net depreciable capital assets are obtained by multiplying, for each quarter, net fixed capital assets by the ratio of net depreciables to net fixed capital assets.

For the years 1955 through 1967, the ratios of net depreciable assets to net fixed assets were computed from data for all active corporations filing income tax returns, as published by the Internal Revenue Service in the *Statistics of Income*. In 1954, the ratios were

[1] In 1962, the categories of balance sheet data published in the *Statistics of Income* did not correspond to the categories published prior to and after 1962. Neither were they available from the Source Book, the comprehensive source from which the *Statistics of Income* data are taken. All of the series obtained from the *Statistics of Income* were linearly interpolated in order to obtain figures for 1962.

TABLE A-1

RATIO OF NET DEPRECIABLE ASSETS TO NET FIXED CAPITAL ASSETS

SIC No.	HIGH	LOW	MEAN
20	.946	.921	.933
22	.981	.959	.973
26	.913	.887	.898
28	.994	.945	.953
29	.881	.787	.844
30	.991	.951	.964
32	.943	.914	.928
33	.943	.913	.927
34	.944	.937	.939
35	.957	.947	.952
36	.971	.950	.961
38	.969	.949	.956

Source: *Statistics of Income,* various annual issues.

computed from all returns of all active corporations who also filed a balance sheet; of the 722,805 corporations filing returns in 1954, 667, 856 (92.4%) filed returns with balance sheets.

At the time the data were being compiled, the 1967 income tax data had not yet been published. The 1967 data were directly obtained from the Internal Revenue Service.

In 1958, changes were made in the *Standard Industrial Classification Manual* [1967]. For most industries, the changes were minor and appear to have had no significant effect on the data. In the category of nonelectrical machinery (SIC 35), however, a number of three-digit industries previously included in nonelectrical machinery were reallocated to other two-digit industries. The result was a reduction in the net capital stock series of approximately 5 percent. For the year 1958, overlapping data were presented in the *Quarterly Financial Reports*; the percentage reduction for each of the four quarters was: I - 5 percent; II - 5 percent; III - 6 percent; IV - 5 percent. In order to standardize the series, therefore, the data for the 24 quarters previous to 1958 were multiplied by a factor of .95 to make the pre-1958 series compatible with the post-1958 series.

Deflation of Net Depreciable Capital Assets. Annual deflators for net depreciable assets at the two-digit industry level were obtained from the National Industrial Conference Board. These deflators represent the ratio of the book value of net depreciables to their 1958 prices. The data are available for the years 1953 to 1965 (except for SIC 34, fabricated metals, where the deflator is available only through 1963). In order to obtain estimates of the deflators for 1952 and through 1968, it was assumed that the capital stock deflators for two-digit industries were closely related to that for all manufacturing. The net depreciable capital stock deflator for all manufacturing was obtained from the Office of Business Economics, Department of Commerce. The annual values of the two-digit industry deflators for the period 1953 to 1965 (1963 for SIC 34) were regressed onto the corresponding values of the deflator for all manufacturing. The resulting relationships, shown in Table A-2, were used to extrapolate the two-digit industry deflators to 1952, and through 1968. These annual estimates were then interpolated linearly to obtain quarterly deflators of net depreciable capital stock at the two-digit industry level.

Reduction of Net Depreciable Capital to NICB Universe Level. The capital appropriations data compiled by the NICB are estimates for a universe consisting of the 1000 largest manufacturing corporations, ranked according to total assets. In the years 1954, 1957, and 1967, the NICB computed estimates of total year end assets, by two-digit industries, of all firms in the 1,000 corporations universe. These total asset figures are divided by total year end assets for all corporations in each two-digit industry, which data are obtained from the *Quarterly Financial Reports*. These ratios are interpolated linearly to provide quarterly estimates of the ratios, for each industry, of the assets of the corporations in the NICB universe to

TABLE A-2

REGRESSION OF INDUSTRY CAPITAL STOCK DEFLATOR ON ALL MANUFACTURING DEFLATOR

SIC No.	R^2	CONS. (t)	COEF. (t)
20	.987	−10.0583 (− 3.497)	1.0253 (29.677)
22	.973	− 4.5046 (− 1.163)	0.9761 (20.983)
26	.998	− 1.5888 (− 1.533)	0.9700 (77.908)
28	.988	−14.8295 (− 4.963)	1.1177 (31.142)
29	.998	− 0.1554 (− 0.155)	0.8808 (72.906)
30	.992	− 6.6356 (− 2.911)	1.0655 (38.917)
32	.998	−20.2170 (−14.988)	1.1698 (72.198)
33	.993	0.6041 (0.307)	0.9393 (39.793)
34	.994	− 2.6875 (− 1.312)	1.0070 (39.696)
35	.997	0.4982 (0.412)	0.9853 (67.785)
36	.939	28.1811 (8.227)	0.5581 (13.564)
38	.996	2.6986 (1.884)	0.9620 (55.920)

the assets of all corporations in the total universe for the period 1955 to 1967. For 1952 to 1954, the 1954 value of the ratio was used for each quarter; for 1968, the 1967 value was used. Finally, these ratios were multiplied by the quarterly net depreciable assets corresponding to the NICB universe data on capital backlogs and appropriations.

Capital Backlog and Investment Data. For the period 1953 to 1967, quarterly estimates of the capital backlog and investment expenditures are obtained from the NICB *Quarterly Survey of Capital Appropriations*. These series are estimates of expenditures and backlogs for the NICB universe of the 1,000 largest manufacturing corporations, by industry.

The investment data and the backlog data are converted to real terms by means of the deflator for gross private domestic fixed nonresidential investment (GPDI). This quarterly series, which is seasonally adjusted, is obtained from Table 8.1 of the *National Income and Product Accounts of the United States* (NIPA) [1967].

Estimation of Rate of Depreciation (δ). The net depreciable capital stock series used in the estimation of δ is that obtained from the *Quarterly Financial Reports*, which has been deflated and reduced to the NICB population level (see the description above). Capital expenditures are obtained from the NICB *Quarterly Survey of Capital Appropriations: Historical Statistics, 1953-1967.* These data are deflated by the investment deflator q. The data cover the period from the 4th quarter of 1954 to the 4th quarter of 1967.[2]

Total Hourly Compensation Per Production Worker

See the appendix in [24] for a description of how these data were constructed.[3,4]

[2]Subsequent to the analysis of the model, an error was found in the algorithm used in estimating δ. The error in δ exceeded .001 in only 2 industries (.00108 in SIC 20, and .00219 in SIC 35); in five of the industries, the error was .00001 or less. These errors should have only negligible effects on the estimated own price variable, and also on the final regression results. The cost of reestimating all equations does not seem justified on the basis of the very minor potential gains in accuracy. Table 3 contains the original estimates of δ.

[3]BLS Data for 1954-1967 are obtained from the *Employment and Earnings Statistics for the United States, 1909-1969* [Bureau of Labor Statistics, 1969]; data for 1968-1969 are obtained from various monthly issues of *Employment and Earnings and Monthly Report on the Labor Force.*

[4]OBE data for 1954-1965 are obtained from the *National Income and Product Accounts of the United States, 1929-1965* [Office of Business Economics, 1969]; data for 1966-1969 are obtained from various monthly issues of the *Survey of Current Business.*

Implicit Rent Per Unit of Capital Services (Own Price of Capital)

The concepts and methods used in the determination of the user cost of capital will be the same as those used by Jorgenson [1965]. Assuming, as Jorgenson does, that capital gains from price changes of capital equipment are considered transitory by the firm, and thus do not affect the user cost of capital, the user cost can be written as:

$$c = q\left[\left(\frac{1 - uv}{1 - u}\right)\delta + \left(\frac{1 - uw}{1 - u}\right)r\right]$$

Investment Deflator (q). The investment deflator used in this formulation of user cost is the deflator for gross private domestic fixed nonresidential investment. This deflator is obtained on a quarterly, seasonally adjusted basis from the NIPA.

Corporate Tax Rate (u). The tax rate is the ratio of corporate profit taxes to corporate profits before tax. The data are available on an annual basis, for two-digit industries, from the NIPA. Federal and state corporate profits tax liability data by industry are taken from the NIPA, as are corporate profits before tax data by industry. Since there is no reason to believe that tax rates are viewed as variable over the year by the firm, the tax rate computed for each year is used for the four quarters in each year.

Proportion of Depreciation Chargeable Against Net Taxable Income (v). The variable v is the ratio of the capital consumption allowance to the current replacement cost of capital. Corporate capital consumption allowance by industry is obtained annually from the NIPA. Current replacement cost is computed as the product of the rate of depreciation (δ) (see below) times the value of the net stock of depreciable assets. For the period 1954 to 1967, the value of the net stock of depreciables is directly obtainable from the *Statistics of Income*, as described under "Net Depreciable Capital Assets." For the period 1951 to 1953, these data are not available. However, the value of net fixed capital assets can be computed. Because the ratios of net depreciable assets to net fixed capital assets are relatively constant over the period 1954 to 1967, it is assumed that they can be extrapolated backwards for the period 1951 to 1953. Multiplying these estimated ratios by the value of net fixed capital stock, estimates of the value of net depreciable assets for the years 1951 to 1953 were obtained. The mean and range of these ratios, for each two-digit industry, for the period 1954 to 1967 have been given in Table A-1 above. Again, the variable v computed on an annual basis is used for all four quarters of the corresponding year.

Proportion of Cost of Capital Chargeable Against Net Taxable Income (w). The variable w is the ratio of net monetary interest to the cost of total capital. Net monetary interest is the difference between interest paid and interest received, and is obtained annually from the *Statistics of Income* for each two-digit industry. The cost of total capital is computed as the product of the cost of capital (r) (see below) times the value of total capital (net fixed capital plus working capital) in current prices. The value of net fixed capital is obtained annually from the *Statistics of Income*, as described under "Net Depreciable Capital Assets." Working capital is in general the sum of cash, net notes and accounts receivable, government investments, inventories, and other current assets, less accounts payable, bonds, notes, and mortgages payable in less than one year, and other current liabilities. The yearly breakdown by specific item included in working capital is given in the following table. The data are obtained

TABLE A-3

ITEMS INCLUDED IN WORKING CAPITAL

YEAR	ITEM NUMBER										
	1	2	3	4	5	6	7	8	9	10	11
1951	X	X	X		X		X	X			
1952	X	X	X		X		X	X			
1953	X	X	X		X		X	X			
1954	X	X	X	X	X		X	X	X		
1955	X	X	X	X	X		X	X	X		
1956	X	X	X	X	X		X	X	X		
1957	X	X	X	X	X		X	X	X	X	
1958	X	X	X	X	X		X	X	X	X	
1959	X	X	X		X	X	X	X		X	X
1960	X	X	X		X	X	X	X		X	X
1961	X	X	X		X	X	X	X		X	X
1963	X	X	X		X	X	X	X			X
1964	X	X	X		X	X	X	X			X
1965	X	X	X		X	X	X	X			X
1966	X	X	X		X	X	X	X			X
1967	X	X	X		X	X	X	X			X

ITEMS:
1. Cash
2. Net Notes and Accounts Receivable
3. Inventories
4. Prepaid Expenses and Supplies
5. Government Investments
6. Other Current Assets, including short term marketable instruments
7. Accounts Payable
8. Bonds, Notes, Mortgages, Payable in Less Than 1 Year
9. Accrued Expenses
10. Deposits and Withdrawable Shares
11. Other Current Liabilities

on an annual basis from the *Statistics of Income*. The variable v is also computed on an annual basis.

Cost of Capital (r). The cost of capital is defined by

$$r = \frac{\text{corporate profits after tax + net monetary interest}}{\text{value of securities}}$$

The value of securities is equal to the value of equity plus the value of debt. The value of equity is given by the ratio of corporate profit after tax to the earnings price ratio. The value of debt is equal to the ratio of net monetary interest to the bond yield. Corporate profits after tax are obtained annually for each industry from the NIPA. The bond yield is a quarterly average of the monthly composite average of yields on industrial bonds; the price earnings ratio (the reciprocal of the earnings price ratio) is a quarterly average of the monthly end of the month average price earnings ratio for industrial common stocks. Both are obtained from *Moody's Industrial Manual* [1970]. Quarterly estimates for net monetary interest and corporate profits after tax are obtained by a linear interpolation of the annual data.