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TOBIN'S Q AND FINANCIAL POLICY

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ABSTRACT

Recent research in macroeconomics has emphasized the importance of linking the financial and real sectors and the need for working with optimizing models. Tobin's Q model of investment would appear to provide a framework that can satisfy these two criteria. In contrast to the original presentation of the Q model, the formal development has not recognized that the firm actively participates in a number of financial markets; in this broader context, we show that Q is likely to be an uninformative and possibly misleading signal for investment expenditures. We then endeavor to turn this negative theoretical result to positive advantage in resolving a number of empirical problems with Q models, but the modifications dictated by the theory receive little support from the data.

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TOBIN'S Q AND FINANCIAL POLICY

I. INTRODUCTION

Uncovering the channels through which financial and monetary variables affect real behavior has been of considerable interest during the past few years, as radical changes in financial markets and monetary policies have been associated with sudden swings in macroeconomic activity. Following the insights of Keynes (1936) and Tobin (1969), a number of researchers have investigated these linkages using the Q model, which relates investment in physical capital to the ratio of the market value of financial claims on the firm and the cost of reproducing its existing stock of capital.[1] When this Q ratio exceeds unity, investors in financial markets are indicating that prospective cash flows are likely to be sufficiently high or discount rates sufficiently low to warrant additional capital spending.

The Q framework is particularly appealing because the abovementioned link between financial variables and investment can be derived from a model of forward-looking, maximizing behavior. Based on a cash flow model in which the firm faces convex costs in adjusting its capital stock, it has been shown that physical investment is determined by marginal Q, defined as the ratio of the discounted future revenues from an additional unit of capital (i.e., the shadow price of capital) to its net-of-tax purchase price (Mussa, 1977; Abel, 1979). Critical to the empirical usefulness of this model is that unobservable marginal Q must be related to observable average Q, defined above as the ratio of financial to physical capital. The conditions under which this connection

[1] Fischer and Merton (1984, p. 83) state that "Q theory, associated particularly with James Tobin, ... is now the preferred theoretical description of investment."

can be drawn have been established in an important paper by Hayashi (1982). From a theoretical perspective, Q investment models are appealing because they incorporate forward-looking behavior, reflect optimal choices, and contain estimated coefficients that are readily identified with underlying structural parameters.[2]

In contrast to the original presentation of the Q model, the formal development has not recognized that the firm actively participates in a number of financial markets. This paper develops a model in which the firm chooses, not only the level of investment expenditures, but also its debt and equity policies. We find that endogenizing financial policy calls into question the usefulness of the Q framework, and show that Q is likely to be an uninformative and perhaps misleading signal for investment expenditures.

This negative theoretical result, however, can have a potentially positive impact on the empirical performance of conventional Q models, which have been disappointing on three counts. First, contrary to the theory, lagged variables have proven significant determinants of investment;[3] the interpretation of these coefficients in terms of the underlying structural model becomes unclear. Second, relative to alternative investment models, Q has not performed adequately in terms of either within sample or out-of-sample

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[2]See Lucas (1976) and Sargent (1981) for a discussion of the advantages of estimating and identifying structural parameters.

[3]For example, see von Furstenberg (1977) and Blanchard and Wyplosz (1981), whose results are based on U.S. quarterly data. Significant lagged variables have also emerged in studies of other countries (United Kingdom, Poterba and Summers, 1983; Mexico, Schwartzman, 1984). Fischer (1983) has argued that lagged Q should be an important determinant of investment spending. There are two objections to his result. First, he enters lags into the maximization problem by assuming that adjustment costs depend on both current and lagged investment, but it is not at all clear what phenomena are being captured by this formulation. Second, the investment schedule that follows from his model is quite different from those actually used in econometric work, and thus the relation between his result and empirically significant lagged variables is not apparent.

statistics (Clark, 1979). Third, the implied structural parameters are quite unreasonable. For example, Summers' (1981, p. 101) estimated adjustment cost coefficient implied that, twenty years after an unexpected change in the economic environment, the capital stock would have moved only three-fourths of the way to its ultimate, steady-state value. In sum, these empirical problems reveal a serious misspecification in conventional formulations of the Q model. Our analysis of endogenous financial policy allows us to link the specification error to omitted variables and to exploit this additional information in econometric estimation.

II. THE THEORETICAL MODEL

A. The Maximand and Conditions Characterizing an Optimum

We begin our analysis by assuming that, in formulating real and financial policies, the managers of the firm act in the interests of shareholders and maximize the value of equity subject to four constraints.[4] First, the firm's technology $\Phi([L(t), K(t), I(t), D(t), d(t)])$ depends positively on labor ($L(t)$) and capital ($K(t)$) inputs, and negatively on the remaining three arguments. We assume that, when incorporating investment goods ($I(t)$) into the production process, the firm incurs adjustment costs, which increase at an increasing rate. These internal costs can be viewed as the movement of real resources from producing output toward installing capital goods, and hence have a deleterious effect on $\Phi[t]$. We further assume that the presence of debt ($D(t)$) in the firm's capital structure creates agency problems (Jensen and Meckling, 1976; Myers, 1977) that lead to restrictions on the firm's operations (e.g.,

[4] See Chirinko (1985, Section II.A) for a derivation of the equity value maximand from the cash flow identities characterizing the firm and for a discussion of alternative cost of capital definitions.

bond covenants) and have a negative effect on net revenues.[5] These agency costs annul the well-known capital structure invariance result of Modigliani and Miller and, since we will be assuming that the demand for securities is perfectly elastic, they are borne entirely by the firm. Negative effects on $\Phi[t]$ also arise from the issue of new debt ($d(t)$), reflecting flotation and transactions costs. Throughout the analysis, we assume sufficient curvature (Inada conditions) on $\Phi[t]$ to ensure interior solutions.[6]

Second, significant analytic convenience is achieved by assuming all debt matures in one period; hence, interest payments are determined by a nominal short-term rate. While a long-rate might seem preferable in analyzing investment decisions, borrowers will be indifferent between a sequence of one-period rates and a long-term rate in the presence of perfect capital markets linking the yields on securities of various maturities. We further assume that debt is retired at an exponential rate η and that the stock of debt is accumulated according to the following equation,

$$\dot{D}(t) = d(t) - \eta D(t). \tag{1}$$

Third, the cost of equity capital ($\rho(t)$) is constrained by the return that investors require to hold financial assets. This return is determined by the rates of taxation, inflation, and time preference faced by investors, and thus $\rho(t)$ is invariant to the conduct of policies affecting physical investment

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[5] A similar formulation has been employed by Barnea, Haugen, and Senbet (1981), Gordon and Malkiel (1981), and Taggart (1985). While the introduction of uncertainty would lead to a stronger motivation for agency problems, such a modification would preclude the derivation of the structural econometric model estimated in Section III.

[6] In most tax systems, interest payments are deductible and, in this model, such a "tax break" is needed to encourage the firm to issue debt despite the costs reflected in $\Phi[t]$. Explicit consideration of taxes has been avoided in the theoretical model for the sake of notational simplicity (cf., fn. 12).

and debt finance.[7]

The final constraint governs the transition of the capital stock through time,

$$\dot{K}(t) = I(t) - \delta K(t), \tag{2}$$

where δ is the exponential depreciation rate.

To determine the real and financial policies that maximize the value of equity subject to these four constraints, we form the current-value Hamiltonian,

$$\begin{aligned} &H[L(s),K(s),I(s),D(s),d(s),\lambda(s),\mu(s)] \\ &\quad = \exp\left(-\int_t^s (\rho(u)du\right) \{\Phi[L(s),K(s),I(s),D(s),d(s)] - w(s)L(s) \\ &\qquad - (i(s)-\pi(s)+\eta)D(s) + d(s) - p(s)I(s) \\ &\qquad + \lambda(s)(I(s)-\delta K(s)) + \mu(s)(d(s)-\eta D(s))\}, \end{aligned} \tag{3}$$

where $w(s)$ and $p(s)$ are the prices of labor services and investment goods, respectively, relative to the price of output (the numeraire good), $i(s)$ the nominal short-term interest rate, $\pi(s)$ the inflation rate, and $\lambda(s)$ and $\mu(s)$ the current-value co-state variables associated with the constraints (1) and (2), respectively. Necessary conditions for the maximization of (3) are obtained by applying Pontryagin's Maximum Principle and, for purposes of the present analysis, we consider the following conditions pertaining directly to physical capital,

$$\lambda(t) = \int_t^\infty \exp\left(-\int_t^s (\rho(u)+\delta)du\right) \Phi_K[s]\, ds, \tag{4a}$$

[7]See Chirinko (1985, Section II.B and Appendix B) for an analysis of a dividend policy equating the costs of retentions and new equity.

$$\lambda(t) = p(t) - \Phi_I[t]. \tag{4b}$$

$$\Phi_K[t]>0, \quad \Phi_I[t]<0$$

Equation (4a) defines the marginal benefit of an additional unit of capital as the sum of current and future marginal products weighted by the rates of discount and depreciation. Along the optimal path, this marginal benefit must equal the total marginal costs of acquiring capital. These involve the sum of purchase and marginal adjustment costs, and the requisite equality is given by (4b).

Unlike the stock of physical capital, the value to the firm of financial capital is negative, as indicated by the following expressions for the shadow price of D(t) derived from the necessary conditions,

$$-\mu(t) = 1 + \Phi_d[t], \tag{5a}$$

$$-\mu(t) = \int_t^\infty \exp(-\int_t^s(\rho(u)+\eta)du)\ [i(s) - \pi(s) + \eta - \Phi_D[s]]\ ds, \tag{5b}$$

$$\Phi_D[t]<0, \quad -1<\Phi_d[t]\leq 0.$$

The marginal benefit of issuing debt equals the receipts (at par) less flotation and transactions costs (5a). The marginal carrying costs of this additional unit of debt are given in (5b) as real interest and retirement payments plus the marginal agency costs associated with debt, all discounted by the cost of capital and weighted by the debt survival factor, $\exp(-\eta)$.

Debt policy is conducted in order to equate the marginal costs of equity and debt. This intuitively plausible result can be seen to hold in the present model by differentiating (5b) with respect to time and rearranging,

$$-\dot{\mu}(t) = -(\rho(t)+\eta)\ \mu(t) - [i(t) - \pi(t) + \eta - \Phi_D[t]], \tag{6a}$$

$$\rho(t) = [[i(t)-\pi(t)+\eta-\Phi_D[t]]\ /\ [1+\Phi_d[t]]] - \eta + \dot{\mu}(t)/\mu(t), \tag{6b}$$

The left and right sides of equation (6b) define the costs of equity and debt, respectively. The term in braces represents the marginal carrying costs of debt grossed-up to reflect the loss due to flotation costs that reduce receipts below the par value of debt. Retirement payments of η per dollar of real debt lower future debt costs; in the absence of flotation costs, retirement payments would disappear from (6b). The final term represents the capital gain or loss arising from alterations in the stock of debt, and ensures that (6b) will hold along the optimal path. In the steady-state where $\dot{\mu}(t) = 0$ (and ignoring momentarily agency and flotation costs), the equality between the costs of equity and debt is apparent, $\rho(t) = i(t) - \pi(t)$.

B. Implications for Q Theory

A particularly attractive feature of Tobin's Q theory is that the unobserved shadow price for physical investment can be linked uniquely and rigorously to observable variables useful in econometric estimation. When financial policy is endogenous, however, we show in this sub-section that such a convenient relationship no longer holds. Key to our demonstration is Proposition I, following from maximizing behavior, that defines the market values of debt (D(t)) and equity (V(t)) in terms of current-period stocks and shadow prices,

PROPOSITION I (the financial value of the firm)

In the presence of perfectly competitive output and factor markets,

$$V(t) + D(t) = \lambda(t)\, K(t) + (\mu(t)+1)\, D(t) \tag{7}$$

if and only if

$\Phi[L(t),K(t),I(t),D(t),d(t)]$ is homogeneous of degree one in all arguments and exponential rates govern the depreciation of K(t) and the retirement of D(t).[8]

In (7), the capitalized value of the firm equals the flow of income to be generated by the existing stock of capital plus the flotation and transaction costs that have been absorbed in order to attain the current level of debt. Under certain restrictions, it has been shown that physical investment is related to the ratio of the shadow price of capital to the relative price of investment goods (Mussa, 1977; Abel, 1979). This ratio is referred to as marginal Q ($Q_M(t)$) but, since the shadow price of capital is unobservable, $Q_M(t)$ is not operationally useful. This problem has been overcome in empirical work by replacing marginal Q with average Q ($Q_A(t)$), defined as "the ratio of the market value of firms to the replacement cost of their assets" (von Furstenberg, 1977, p. 347). In terms of our notation, these two definitions can be stated as follows,

$$Q_M(t) = \lambda(t) / p(t), \tag{8a}$$

$$Q_A(t) = (V(t) + D(t)) / p(t) K(t) \tag{8b}$$

and when combined with (7), lead to the following result,

<u>PROPOSITION II (marginal Q and average Q)</u>

$$Q_M(t) = Q_A(t) - (\mu(t)+1) * (D(t)/p(t)K(t)). \tag{9}$$

Proposition II indicates that $Q_M(t)$, which serves as the signal for alterations in $K(t)$, is related to $Q_A(t)$ and an additional term containing an unobserved shadow price. When financial policy is exogenous, this latter term does not appear, and marginal and average Q are equivalent.[9] However, in the presence

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[8] A proof is contained in Chirinko (1985, Apppendix A); cf., Hayashi (1982).

[9] See Summers (1981), Poterba and Summers (1983), and Chirinko (1984) for derivations with exogenous financial policy. Under the current tax code, average Q will have to be decremented by the discounted value of tax depreciation allowances that are attributable to capital assets purchased prior to period t but that will be charged against income in current and future

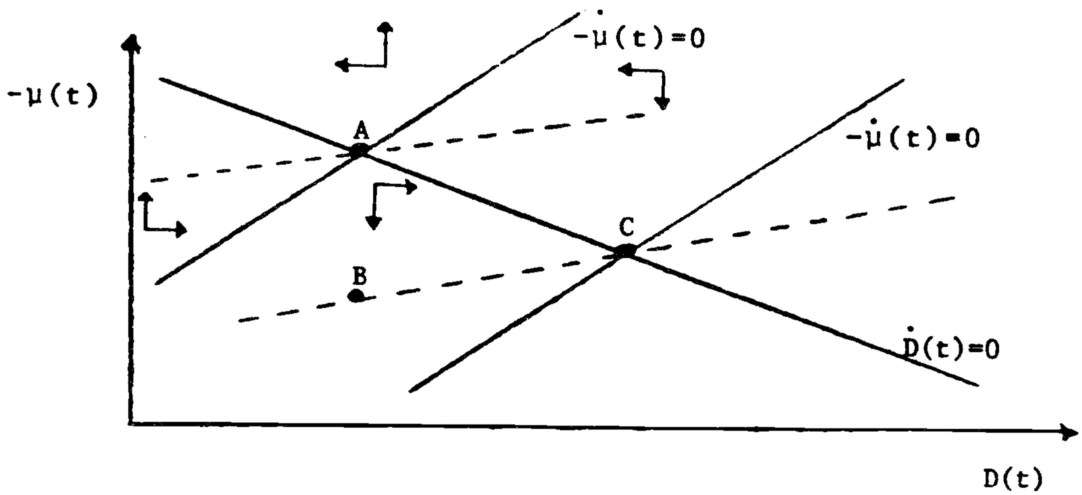
(Footnote continued)

of endogenous financial decisions, $Q_A(t)$ no longer proves to be a "sufficient statistic" for indicating profitable investment opportunities in physical capital.[10]

Not only can $Q_A(t)$ be uninformative, it may also be misleading. In order to demonstrate that $Q_A(t)$ can increase while $Q_M(t)$ remains fixed, we assume that the technology takes the following separable form,

$$\Phi[L(t),K(t),I(t),D(t),d(t)] = \phi^1[L(t),K(t)] - \phi^2[I(t),K(t)] - \phi^3[D(t),d(t)], \tag{10}$$

where the ϕ's capture production, adjustment cost, and agency/flotation cost relationships, respectively, and construct the following phase diagram from (1) and (6a),



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[9](continued)
periods (Hayashi, 1982). The computation of the discounted values associated with tax depreciation will involve variables unknown at time t, and thus attenuate the desirable informational properties of the Q model. Since the primary variation in Q is likely to be due to other factors, it is doubtful that this problem will have much influence on econometric estimates.

[10]As discussed in Chirinko (1982a, 1984) and Wildasin (1984), $Q_A(t)$ is also not a "sufficient statistic" when the firm's production possibilities depend on many physical capital stocks (e.g., equipment and structures).

where the dashed lines represent the saddlepoint paths to the steady-states.[11] Assume that the firm is in a steady-state (A) and that the nominal rate of interest it pays on debt unexpectedly decreases.[12] In this scenario, (5b) implies that the fall in $i(t)$ will lower initially the marginal cost of debt finance $(-\mu(t))$; in terms of the diagram, $-\mu(t)$ falls instantaneously from A to B on the transition path to the new steady-state (C). From (4a) and under our separability assumptions, $\lambda(t)$ and $Q_M(t)$ will be unaffected. Immediately after the fall in $i(t)$ and $-\mu(t)$ but before the firm can alter $D(t)$, $Q_A(t)$ must rise in order to maintain (9) and to reflect the cheaper finance now available to the firm.[13] As the firm acquires debt along the transition path to the new steady-state, both $-\mu(t)$ and $D(t)$ will rise, and $V(t)$ will fall until $Q_A(t)$ retains its steady-state value. Between steady-states, $Q_A(t)$ would have been signaling profitable investment opportunities in <u>financial</u>, not <u>physical</u>, capital. Thus, relating the flow of physical investment to $Q_A(t)$, as is done in conventional specifications of Q models, may meet with only limited

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[11]The phase diagram is based on the following properties for $\phi^3[D(t), d(t)]$: $-\Phi_d[t] = \phi^3_d[t] > 0$, $-\Phi_{dd}[t] = \phi^3_{dd}[t] > 0$, $-\Phi_D[t] = \phi^3_D[t] > 0$, $-\Phi_{DD}[t] = \phi^3_{DD}[t] > 0$. See Chirinko (1985, Appendix C) for a more detailed discussion of the phase diagram.

[12]If we interpret $i(t)$ as the net-of-tax interest rate, then this unexpected change could be due to government policies that alter the degree to which interest payments may be deducted against business income or the rate of business income taxation. (Examples of both of these changes can be found in tax reform proposals advanced by the Reagan Administration.) With additional notation, it is straightforward to incorporate taxes into the Hamiltonian (3).

[13]In terms of the notation, we have that $dQ_A(t) = dV(t) = -d(-\mu(t))D(t) > 0$.

empirical success. However, as demonstrated in the next section, we will be able to regain a useful structural relationship by conditioning on variables associated with debt finance.

III. THE ECONOMETRIC MODEL

A. Specification Issues

In this section, we exploit the information provided by the model with endogenous financial policy, and generate estimates of the structural parameters. To translate the theoretical model of Section II into an econometric equation, we need to parameterize the adjustment cost and flotation/agency cost functions. We assume that adjustment costs depend on net investment,

$$\phi^2(I(t),K(t)) = (\alpha/2)\,[I(t)/K(t) - \delta]^2\, K(t), \tag{11}$$

where α and δ are unknown parameters to be estimated. Differentiating (11) with respect to I(t), inserting the result into (4b), and utilizing (7), we obtain the following investment relationship,

$$I(t) = \delta\, K(t) + (1/\alpha)\, \Omega(t) - (1/\alpha)\, (\mu(t)+1)\, D(t), \tag{12}$$

$$\Omega(t) = V(t) + D(t) - p(t)\, K(t),$$

where $\Omega(t)$ is the difference between the financial value of the firm and its replacement cost. (This latter term is closely related to $Q_A(t)$; if adjustment costs were valued by the price of investment goods rather than output, $\Omega(t)$ in (12) would be replaced by $Q_A(t)$.) The first term in (12) represents replacement investment, which is proportional to the capital stock; $\Omega(t)$ indicates the profitable level of investment activity - both physical and financial - for the firm. The last term is the unobservable shadow price associated with debt, and represents flotation costs that are positively related to $\Omega(t)$. Thus, for a given movement in $\Omega(t)$, the amount of resources available for additions to physical capital will be lowered by the costs associated with the flow of debt used to finance the marginal project. It should be noted that (12) will be immune from the problem discussed in Section II.B of $Q_A(t)$ generating misleading signals. Under that scenario, $dV(t) = -d(-\mu(t))D(t)$ (cf., fn. 13), and $dI(t)$ calculated from (12) would be zero. Conventional formulations of the Q model have ignored the effect of endogenous financial policy and, in order to gauge its importance on econometric estimates, we postulate the following agency/flotation cost function,

$$\phi^3(D(t),d(t)) = D(t)^\sigma \, d(t)^\gamma, \qquad (13)$$

$$\gamma \geq 0, \ \sigma \geq 0, \ D(t)>0, \ d(t)>0$$

where σ and γ are parameters to be estimated. It should be noted that both (11) and (13) satisfy the curvature properties on $\Phi[t]$ discussed in the text.[14]

An additional assumption underlying the Propositions I and II was that the $\phi(.)$'s were all homogeneous of degree one. While this assumption may be plausible for the production and adjustment cost technologies, it is arguably inappropriate in regard to debt-related costs. If flotation and agency costs have a large fixed-cost component, then $\sigma+\gamma$ may be less than one; if marginal flotation costs are positive and agency costs increase at an increasing rate, then $\sigma+\gamma$ may be greater than one. To allow for the possibility that $\sigma+\gamma\neq1$, Propositions I and II are restated as follows,

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[14]Should $\Phi_{dd}=-\phi^3_{dd}>0$, then the firm would be willing to supply an infinite amount of debt in order to exploit the concavity in its cost structure. To eliminate this possibility, we impose legal constraints against paying dividends in excess of (long-run) operating profits and accumulating excess funds within the firm. In this case, the firm's additional debt issues must be used to finance investment, which, if the adjustment cost function is sufficiently convex, will bound $d(t)<\infty$.

PROPOSITION I' (the financial value of the firm)

Given the assumptions in Proposition I,

$$V(t) + D(t) = \lambda(t)\, K(t) + (\mu(t)+1)\, D(t) + \chi(t),$$

$$\chi(t) = (\sigma+\gamma-1) \int_t^{\infty} \exp(-\int_t^{s} \rho(u))\, [D(s)^{\sigma}\, d(s)^{\gamma}]\, ds \tag{14}$$

if and only if

$\phi^1(L(t),K(t))$ and $\phi^2(I(t),K(t))$ are homogeneous of degree one in all arguments, $\phi^3(D(t),d(t))$ is homogeneous of degree $\sigma+\gamma$, and exponential rates govern the depreciation of $K(t)$ and the retirement of $D(t)$.

PROPOSITION II' (marginal Q and average Q)

$$Q_M(t) = Q_A(t) - (\mu(t)+1) * (D(t)/p(t)K(t)) - \chi(t)/p(t)K(t). \tag{15}$$

Note that Propositions I and II are special cases of Propositions I' and II' when $\sigma+\gamma=1$ ($\chi(t)=0$), and thus it will be straightforward to test the assumption of increasing debt costs. When we allow for the possibility of this more general situation, the marginal value of an additional unit of physical capital is lowered by the differential debt costs - those that differ from constant average cost - summed and discounted over the life of the firm. Since $\chi(t)$ extends over an infinite horizon, $Q_M(t)$ in (15) is related to both current and future variables. Believing that a substantial amount of the variation in $\chi(t)$ can be captured by current movements in the rate of discount and stock of debt, we compute $\chi(t)$ under the assumption that $\rho(s)=\rho(t)$, $D(s)=D(t)$, and $d(s)=\eta D(t)$, for all $s \geq t$. Differentiating (13) with respect to $d(t)$, inserting the result into (5a), and utilizing (1), (8), (12), (13), and (15), we obtain the following structural econometric equation,

$$
\begin{aligned}
I(t) / K(t) &= \delta + (1/\alpha)\ \Omega(t) / K(t) \\
&- (\gamma/\alpha)\ [\dot{D}(t)/D(t)+\eta]^{\gamma-1}\ D^{\sigma+\gamma} / K(t) \\
&- (\sigma+\gamma-1)\ (1/\alpha)\ \eta^{\gamma}\ [D(t)^{\sigma+\gamma} / \rho(t)] / K(t) \\
&+ \psi\ I(t-1) / K(t) + \varepsilon(t),
\end{aligned}
\tag{16}
$$

where all terms have been scaled by K(t) to avoid the spurious correlation possible with variables trending upward over time (Granger and Newbold, 1974). Our review of estimated Q models indicated that lagged variables have proven significant, and the lagged flow of physical investment has been added to (16) to capture any dynamic effects not fully accounted for by the adjustment cost technology.[15] A significant value of ψ can be interpreted as a sign of misspecification in our econometric model. Lastly, $\varepsilon(t)$ is a white-noise error term that reflects non-systematic variations in I(t) and approximation errors that have arisen in the development of the model.

Equation (16) stands in sharp contrast to previously estimated investment models utilizing an adjustment cost technology (11) but maintaining an exogenous financial policy. In the latter case, debt ratios affect investment decisions through the purchase price of new capital (p(t)) in much the same way as investment tax credits.[16] If the cost of debt is lower than equity, the marginal investment expenditure receives a subsidy equal to the capitalized difference in financing costs, a profit opportunity that firms constrained by an exogenous financial policy fail to exploit. When the choice of financing is

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[15] It should be noted that the addition of the lagged dependent variable compromises the structural interpretation of (16).

[16] See Chirinko (1984), whose formula differs from that of Summers (1981) and Poterba and Summers (1983). The current analysis suggests that Poterba and Summers' tests of the effects of dividend taxation within the Q framework may be biased by their assumption of an exogenous financial policy. For example, in 1965, changes in the United Kingdom tax code penalized dividends while favoring debt finance (King, 1977, Table 7.1).

determined simultaneously with physical investment, the profit opportunity vanishes, and (16) indicates that the conventional Q model is misspecified. It is possible that the emergence of significant lagged variables in previously estimated Q models and their generally disappointing empirical performance may be due to the omitted debt terms in (16). Furthermore, a standard analysis of omitted variables bias suggests that the conventional Q specification is likely to generate estimated values of the adjustment cost parameter (α) that are biased upward.[17] Whether endogenizing financial policy within the Q framework mitigates some of these empirical problems is considered in light of the econometric results presented in the next sub-section.

B. Econometric Results

The structural equation following from the theoretical model was estimated with annual data for the nonfinancial corporate sector over the period 1950-1981. The length of the sample was dictated by data availability, and detailed information concerning data sources is contained in the Glossary. While the theory implies that all capital inputs affecting the firm should be included in the series for the capital stock and investment flow, data availability forces us to define capital as either equipment + structures (the ES model) or equipment + structures + inventories (the ESI model). As we shall see, the lessons to be drawn from this paper are robust with respect to the definition of capital.

Estimates of the nonlinear model (16) are presented in Table I, and are computed by full information maximum likelihood, which, under the present circumstances, is equivalent to nonlinear least squares.[18] A number of the

[17] This conclusion is based on the assumption of a positive correlation between $[\Omega(t)/K(t)]$ and $[(d(t)/D(t))^{\gamma-1}D(t)/K(t)]$ and on the constraint $\sigma=1-\gamma$, where γ is the "true", as opposed to the estimated, value of the parameter.

TABLE I

TWO OR THREE CAPITAL STOCKS*

NONLINEAR LEAST SQUARES/FIML

Parameter or Statistic	Equipment + Structures			Equipment + Structures + Inventory		
	(1)	(2)	(3)	(4)	(5)	(6)
δ	.028 (.030)	.029 (.031)	.031 (.029)	.067[a] (.021)	.068[a] (.024)	.071[a] (.024)
α	195.909[b] (82.132)	183.732 (95.784)	209.608[b] (91.047)	83.682[a] (28.287)	75.222[a] (25.427)	79.802[a] (24.711)
γ	0.0 ---	1.953 (8.176)	17.668 (161.900)	0.0 ---	1.940 (5.790)	6.366 (9.531)
$\tilde{\sigma}$	1.0 ---	1.0 ---	3.850 (32.822)	1.0 ---	1.0 ---	1.953 (1.892)
σ	--- ---	-.953 (8.176)	-13.818 (129.150)	--- ---	-.940 (5.790)	-4.413 (7.650)
ψ	.781[a] (.221)	.777[a] (.217)	.757[a] (.216)	.345 (.200)	.343 (.201)	.327 (.216)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.468	.456	.448	.293	.301	.334
m	1.997	2.100[b]	2.226[b]	3.690[a]	4.322[a]	3.945[a]
RSS	.232	.229	.224	.487	.465	.427
Log L	107.132	107.309	107.636	95.243	95.965	97.354

*Equation (16). Sample period is 1950-1981. m is a test statistic for first-order serial correlation in the residuals, and is distributed t under the null hypothesis of no serial correlation (cf., fn. 19); RSS represents the residual sum of squares (multiplied by 10^{-2}); Log L represents the log likelihood statistic; and $\tilde{\sigma}$ equals $\gamma + \sigma$. Standard errors in parantheses.

[a]Significant at the 1% level.

[b]Significant at the 5% level.

empirical problems with the conventional Q model (columns 1 and 4) are readily apparent - the $\bar{R}^2$'s are low, the lagged dependent variable in the ES model is significant, and the residuals are serially correlated.[19] Furthermore, the α's are larger than the value underlying the simulation result cited in Section I, and thus they imply a very slow response of the capital stock to unexpected changes in the economic environment.[20] Adjusted for the difference in the mean of $\Omega(t)$ between the ES and ESI models, the α for the conventional ES model becomes 109.2 and, consistent with the adjustment cost interpretation of this parameter, indicates that the problem of long adjustment paths is more serious when we confine our attention to fixed capital.

The extent to which the analysis of financial policy alleviates these problems can be assessed in a number of ways. The Q model with endogenous financial policy nests the conventional specification, and the parametric restrictions can be analyzed by a sequential testing procedure. In particular, we can evaluate the following three hypotheses stated in terms of γ and σ:

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[18] See the Appendix for a discussion of estimation issues and for additional tables. Note that η has been set to .15 in all of the reported estimates.

[19] Serial correlation is assessed by the m-statistic, distributed t under the null hypothesis of no serial correlation. The m-statistic is calculated in a regression of the residuals from an equation with a lagged dependent variable (16) on all of the explanatory variables in the initial regression plus the lagged residual; m is the t-statistic on the lagged residual. Performing a t-test on this coefficient is asymptotically equivalent to the Durbin h-test. However, it can be calculated for all possible values of the estimated parameters, and has performed better than the h-statistic in Monte Carlo experiments (Harvey, 1981, p. 276).

[20] Summers' (1981) preferred estimate of α is 32.258. Adjusted for the difference in the means of $\Omega(t)$, the comparable α's from Table I are 133.761 and 102.538 for the ES and ESI models, respectively.

H_3: $\gamma=\hat{\gamma}$, $\sigma=\hat{\sigma} \rightarrow \tilde{\sigma}=\hat{\gamma}+\hat{\sigma}$; General

H_2: $\gamma=\hat{\gamma}$, $\sigma=1-\hat{\gamma} \rightarrow \tilde{\sigma}=1$; Constant Returns to Scale in $\phi^3(.)$

H_1: $\gamma=0$, $\sigma=1 \rightarrow \tilde{\sigma}=1$; Conventional

where the "^" denotes estimated values, $\tilde{\sigma}$ is defined as the sum of γ and σ, and the subscripts on H correspond to columns 1-3 for the ES model or columns 4-6 for the ESI model, respectively. The hypotheses are evaluated in increasing order of restrictiveness by likelihood ratio tests, and an advantage of this procedure is that the incremental test statistics are all independent in large samples (Harvey, 1981, pp. 184-185). For both the ES and ESI models, the restrictions characterizing the conventional model are sustained through both steps of the sequential testing procedure at the 5% level, which implies a nominal significance level of 9.75% for the test of the conventional versus general Q specification. Complementary evidence is provided by the m-statistic, indicating that the serial correlation in the residuals remains when the debt-related variables are introduced. This problem is not mitigated by imposing a second lag of the dependent variable (see Table A-I in the Appendix). Combined with negative (though insignificant) σ's and largely unchanged α's, these results suggest strongly that the source of misspecification in Q models is not related to the treatment of financial policy.

One possible problem with these results is that they may be affected by simultaneity bias. In (16), all of the stock and asset price variables are dated at the beginning of the period; hence, the only variable that might be correlated with the error term is the current flow of debt. Nonlinear instrumental variable estimates are presented in Table II, and the results are quite similar to those obtained in Table I.[21]

TABLE II

TWO OR THREE CAPITAL STOCKS*

NONLINEAR INSTRUMENTAL VARIABLES

Parameter or Statistic	Equipment + Structures			Equipment + Structures + Inventory		
	(1)	(2)	(3)	(4)	(5)	(6)
δ	.028 (.030)	.028 (.035)	.028 (.046)	.067[a] (.021)	.068[b] (.032)	.067[a] (.023)
α	195.909[b] (82.132)	188.832 (179.590)	190.643 (215.397)	83.682[a] (28.287)	77.748[b] (31.495)	69.180[a] (22.216)
γ	0.0 ---	2.526 (28.383)	1.734 (45.191)	0.0 ---	1.984 (11.607)	4.101 (11.173)
$\tilde{\sigma}$	1.0 ---	1.0 ---	.839 (7.516)	1.0 ---	1.0 ---	1.631 (2.375)
σ	--- ---	-1.526 (28.383)	-.895 (48.442)	--- ---	-.984 (11.607)	-2.470 (8.810)
ψ	.781[a] (.221)	.777[a] (.224)	.778[a] (.226)	.345 (.200)	.345 (.197)	.374 (.203)
η	---	.150	.150	---	.150	.150
m	1.997	2.056[b]	2.071[b]	3.690[a]	3.795[a]	3.725[a]
RSS	.232	.229	.230	.487	.466	.462

* See the notes at the foot of Table I. The instrument set comprised a constant, a time trend, the level of output lagged one period, $\Omega(t)/K(t)$, $D(t)/K(t)$, and $I(t-1)/K(t)$.

Stepping outside of the formal model, we consider the impact of two additional variables that may be significant determinants of spending for fixed investment.[22] First, an important assumption implicit in our derivation of the investment equation was that the firm was always able to equate the marginal costs of alternative sources of finance. During those periods when the firm may not have ready entree to the capital markets, the presence of internal funds may prove important in financing investment expenditures and, to test their importance, current cash flow is entered as an additional regressor. The results are displayed for the ES model in the first three columns of Table III, and reveal a significant role for liquidity but at the expense of $\Omega(t)$. When the model is estimated with instrumental variables, however, this significant effect disappears.[23] Second, while demand conditions are explicitly accounted for in the derivation of the Q model, it is possible that $\Omega(t)$ is unable to capture the full extent of this influence. For the ES model in Table IV, the demand variable - the percentage change in the constant dollar gross domestic product of nonfinancial corporations - enters with a positive and significant

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[21]The instrument set comprised a constant, time trend, the level of output lagged one period, $\Omega(t)/K(t)$, $D(t)/K(t)$, and $I(t-1)/K(t)$. The results reported in Table II were robust with respect to variations in the instrument list. In the presence of serially correlated residuals, it would be preferable to lag the instruments an additional period. However, the correlations between these instruments and the variables in (16) were too weak to deliver any reliable results.

[22]Parallel results for the ESI model can be found in the Appendix. For both the ES and ESI models, $\Omega(t-1)/K(t)$ and a time trend were entered separately as additional regressors, both of which were significant and led to a substantial decline in α. Visual inspection of the residuals from a number of regressions revealed a large, negative residual recurring in 1958. Except for a rejection of H_3 versus H_2 at the 5% level in the ESI model, the use of a dummy variable for 1958 had little effect on the results of interest.

[23]This result would not appear to be due to weak instruments, as the R^2 between the liquidity variable and a constant, time trend, the level of output lagged one period, $\Omega(t)/K(t)$, $D(t)/K(t)$, $I(t-1)/K(t)$, and $LIQ(t-1)/K(t)$ is .70 and .79 for the ES and ESI models, respectively.

TABLE III

TWO CAPITAL STOCKS WITH A LIQUIDITY VARIABLE*

(ξ* LIQ(t)/K(t))

NONLINEAR LEAST SQUARES/FIML OR NONLINEAR INSTRUMENTAL VARIABLES

Parameter or Statistic	NLSQ/FIML			NLIV		
	(1)	(2)	(3)	(4)	(5)	(6)
δ	.011 (.029)	.012 (.032)	.011 (.037)	.015 (.030)	.016 (.033)	.014 (.031)
α	303.564 (214.912)	295.264 (261.319)	292.663 (323.492)	268.240 (166.913)	260.037 (294.653)	286.246 (174.194)
γ	0.0 ---	3.592 (22.877)	1.018 (4.940)	0.0 ---	2.937 (36.208)	.019 (1.352)
$\tilde{\sigma}$	1.0 ---	1.0 ---	.821 (5.307)	1.0 ---	1.0 ---	.815 (4.046)
σ	--- ---	-2.592 (22.877)	-.197 (6.716)	--- ---	-1.937 (36.208)	.796 (3.541)
ψ	.805[a] (.203)	.803[a] (.217)	.805[a] (.217)	.799[a] (.212)	.797[a] (.212)	.799[a] (.216)
ξ	.172[b] (.068)	.169[b] (.081)	.171 (.088)	.130 (.132)	.128 (.145)	.131 (.148)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.518	.500	.483	---	---	---
m	1.577	1.609	1.590	1.624	1.652	1.590
RSS	.203	.203	.202	.205	.204	.207
Log L	109.219	109.257	109.299	---	---	---

*See the notes at the foot of Tables I and II and fn.23.

TABLE IV

TWO CAPITAL STOCKS WITH A DEMAND VARIABLE*

$(\xi * \dot{Y}(t)/Y(t))$

NONLINEAR LEAST SQUARES/FIML OR NONLINEAR INSTRUMENTAL VARIABLES

Parameter or Statistic	NLSQ/FIML (1)	NLSQ/FIML (2)	NLSQ/FIML (3)	NLIV (4)	NLIV (5)	NLIV (6)
δ	-.016 (.018)	-.016 (.019)	-.016 (.019)	-.083 (.043)	-.085 (.051)	-.085 (.043)
α	558.878 (605.278)	545.643 (741.373)	536.625 (713.350)	-306.617 (371.440)	-281.666 (387.113)	-250.019 (304.954)
γ	0.0 ---	.944 (1.616)	.889 (2.429)	0.0 ---	1.986 (34.926)	3.972 (17.485)
$\tilde{\sigma}$	1.0 ---	1.0 ---	.903 (3.256)	1.0 ---	1.0 ---	1.643 (3.649)
σ	--- ---	.056 (1.616)	.014 (3.060)	--- ---	-.986 (34.926)	-2.328 (13.860)
ψ	1.093^a (.134)	1.096^a (.138)	1.094^a (.156)	1.568^a (.308)	1.578^a (.312)	1.576^a (.293)
ξ	$.156^a$ (.028)	$.157^a$ (.029)	$.156^a$ (.030)	$.394^a$ (.110)	$.398^a$ (.120)	$.393^a$ (.106)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.675	.662	.649	---	---	---
m	1.331	1.342	1.380	-.274	-.162	.175
RSS	.137	.137	.137	.357	.357	.313
Log L	115.514	115.531	115.560	---	---	---

*See the notes at the foot of Tables I and II.

coefficient and serial correlation in the residuals disappears. The estimated value of α is raised substantially, but becomes insignificant. Unlike the results for liquidity, the demand variable remains significant with instrumental variables, confirming the often-observed sensitivity of investment spending to demand.

IV. SUMMARY AND CONCLUSION

Recent research in macroeconomics has emphasized the need for working with optimizing models and the importance of linking the financial and real sectors of the economy. Tobin's Q model of investment would appear to provide a framework that could satisfy these two criteria. However, when the firm actively participates in more than one financial market, we have shown that Q is likely to be an uninformative and possibly misleading signal for investment expenditures.

We have endeavored to turn this negative theoretical result to positive advantage in resolving a number of problems with the empirical performance of Q models. In the presence of endogenous financial policy, a structural investment model can be preserved as long as the estimates are conditioned on debt-related variables. Unfortunately, such modifications to the conventional Q model receive little support from the data. Relative to the specification incorporating endogenous financial policy, the conventional Q model was sustained in a sequential testing procedure, and a number of empirical problems remained under the more general specification - slow adjustment speeds, significant lagged variables, and serially correlated residuals. In addition, demand conditions, proxied by the percentage change in output, proved quite significant at the expense of the Q variable. Thus, on both theoretical and empirical grounds and contrary to the sanguine view expressed recently by Fischer and Merton (1984), we conclude that Q theory is unlikely to provide the basis for a satisfactory investment model linking the financial and real sectors. Whether a suitable framework is to be found by modifying the adjustment cost technology or by introducing additional dynamic elements remains an open question for future research.

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GLOSSARY AND DATA SOURCES

For ease of exposition, the model developed in the text avoided considering taxes, an omission that can not be maintained in the econometric analysis. Tax variables enter the structural econometric model (16) only through $\Omega(t)$, and three modifications are necessary - lowering the replacement cost of capital to reflect the subsidies provided by the investment credit and depreciation allowances; adjusting the price of output to reflect the rate of corporate income taxation; and subtracting from $\Omega(t)$ the value of tax depreciation allowances on real assets purchased prior to t. The calculation of this latter term is somewhat involved, and the use of available series would have shortened the sample period. Since the bulk of the variation in $\Omega(t)$ is attributable to the financial assets, the adjustment for the value of existing depreciation allowances has not been made. Comparing regressions based on this adjustment to those contained in Table I indicates that the results, while slightly improved, are not appreciably affected. The correlation of $\Omega(t)$'s with and without this adjustment is always greater than .95 (time series for the value of existing depreciation allowances were taken from CO and HA). As far as possible, all data pertain to the nonfinancial corporate sector. Sources and descriptions of the series used in the estimation are detailed below.

SOURCES

BAL - Board of Governors of the Federal Reserve System, "Balance Sheets for the U.S. Economy, 1945-82," (October 1983).

BEAU - Unpublished data provided by the Bureau of Economic Analysis.

BS - U.S. Department of Commerce, Bureau of Economic Analysis, Business Statistics (1982, 1971).

CO - Corcoran, Patrick J., "Inflation, Taxes, and the Composition of Business Investment," Federal Reserve Bank of New York Quarterly Review 4 (Autumn 1979), 13-24, and unpublished data provided by the author.

CS - Corcoran, Patrick J., and Sahling, Leonard, "Business Tax Policy in the United States: 1955-1980," Federal Reserve Bank of New York, Research Paper No. 8102 (September 1981), and unpublished data provided by the authors.

HA - Hayashi, Fumio, "Tobin's Marginal q and Average q," Econometrica 50 (January 1982), p. 222, Table I.

NIPA - U.S. Department of Commerce, Bureau of Economic Analysis: (1979-1982), Survey of Current Business 63 (July 1983); (1976-1978), Survey of Current Business 62 (July 1982); (1940-1975), The National Income and Product Accounts of the United States 1929-1976 Statistical Tables (September 1981).

ST - Seater, John J., "Marginal Federal Personal and Corporate Income Tax Rates in the U.S., 1909-1975," Journal of Monetary Economics 10 (November 1982), 361-381.

S&P - Standard & Poor's Statistical Service, Security Price Index Record, 1984.

VF - von Furstenberg, George M., "Corporate Investment: Does Market Valuation Matter in the Aggregate?," Brookings Papers on Economic Activity (1977:2), 347-397

DEFINITIONS

D = Constant dollar market value of debt issued by nonfinancial corporate business, beginning of the period (BOP): D$ / p_{gnp}.

D$ = Current dollar market value of debt issued by nonfinancial corporate business, BOP: (NETINT * (MIP / INT)) / i).

DIV = Current dollar dividends for nonfinancial corporate business, BOP: NIPA, Table(T)1.13, Line(L)31.

DSP_c = Standard & Poor's dividend-common stock price ratio, BOP: S&P, p. 127.

DSP_p = Standard & Poor's dividend-preferred stock price ratio, BOP: S&P, p. 118.

i = Moody's nominal interest rate on corporate Aaa bonds, BOP: NIPA S-16 and BS.

I_j = Constant dollar investment for nonfinancial corporate business (j = equipment, structures, inventories), flow for the current period: BEAU.

INT = Current dollar net interest paid by nonfinancial corporate business, flow for the previous period: NIPA, T1.13, L35.

k_{es} = Rate of investment credit for equipment and structures, average for the period (AVG): CS, p. 54.

K_j = Constant dollar replacement value of the capital stock for nonfinancial corporate business (j = equipment, structures, inventories), BOP: BEAU.

$K_j\$$ = Current dollar replacement value of the capital stock for nonfinancial corporate business (j = equipment, structures, inventories), BOP: BAL, T705, L4.

LIQ = Constant dollar cash flow, defined as after-tax corporate profits without inventory valuation and capital consumption adjustments for nonfinancial corporate business divided by the implicit price deflator for gross national product for the middle of the period, flow for the current period: NIPA, T.1.13, L30 divided by Pgnp (adjusted to the middle of the period).

MIP = Current dollar net monetary interest paid by nonfinancial corporate business, flow for the previous period: NIPA, T8.7, L7 less L25.

NETINT = Current dollar net interest paid by nonfinancial corporate business, BOP: NIPA, T.1.13, L35.

NFA = Current dollar noninterest bearing net financial assets of nonfinancial corporate business, BOP: BAL T705, L9, L16, L17, L18, less L37, L38, L39.

p_{gnp} = Implicit price deflator for gross national product, BOP: NIPA, T7.1, L1.

ρ = Shareholders' real rate of discount, BOP: $(\omega_{div}\ DSP_c + (1-\omega)\ DSP_p) + .032$, where the latter number equals the average percentage increase in Standard & Poor's stock price index less the rate of inflation over the sample period.

$TXTOT_p$ = Current dollar property tax accruals to state and local governments, total, AVG: NIPA, T3.5, L24.

τ_c = Rate of taxation of corporate income, AVG: $\tau_f + \tau_s - \tau_f\tau_s$.

τ_f = Rate of federal taxation of corporate income, AVG: ST, T2, C6.

τ_p = Rate of taxation of property, AVG: $TXTOT_p$ multiplied by (BAL, T701, L7, L13, plus L25 less L8 less L15).

τ_s = Rate of state and local taxation of corporate income, AVG: NIPA, T3.3, L6 divided by NIPA, T1.12, L8 plus $TXTOT_p$.

τ_{es} = Tax effects on capital services, equipment and structures, AVG: $(1 + \tau_p(1-\tau_c)) * (1- k_{es} - \tau_c z_{es})$.

τ_i = Tax effects on capital services, inventories, AVG: $(1 - \tau_c \exp[-cg * .25 * .75])$, where cg is the nominal capital gain on inventories, .25 is the age of the inventory stock, and .75 is the percentage of the value of inventories under first-in, first-out accounting methods.

V = Constant dollar market value of equity for nonfinancial corporate business, BOP: V$ / p_{gnp}.

V$ = Current dollar market value of equity for nonfinancial corporate business, BOP: DIV / $(\omega_{div}\ DSP_c + (1-\omega_{div})\ DSP_p)$.

Ω = Difference between the value of the firm evaluated on financial markets and the net-of-tax replacement value of its assets, BOP: $[(V\$ + D\$) - (\tau_{es}K_{es}\$ + \tau_i K_i\$ + NFA)] / (1-\tau_c)\ p$.

ω_{div} = Percentage of dividends paid on common stock, AVG: VF, p. 358, fn. 11, extended for the current study.

Y = Constant dollar gross domestic product for nonfinancial corporate business, flow for the current period: NIPA, T1.13, L36.

z_{es} = Present discounted value of current and future tax depreciation allowances per dollar of current investment in equipment and structures, AVG: CS, Appendix E.

APPENDIX. ESTIMATION ISSUES AND ADDITIONAL RESULTS

All computations were performed with version 4.0E of TSP on the VAX 780 at the Hoover Institution. The Davidon-Fletcher-Powell algorithm was used, and the convergence criteria was set at .05 percent. In order to obtain consistent estimates of the standard errors, the converged model was iterated an additional time using the method proposed by Berndt, Hall, Hall, and Hausman (1974). These were generally larger than those obtained under nonlinear least squares.

Two problems were encountered in performing the computations. First, direct estimates of η were not obtainable, and a grid search was conducted over a range of admissible values. This range was restricted by the flotation/agency cost function (13), which, if $d(t)\geq 0$, implies that $\eta \geq -\dot{D}(t)/D(t)$. Given our time series for $D(t)$, η must equal or exceed .15, a value implying that, after 20 years, 95% of a debt issue would be retired. The model was estimated for η's between .15 and .30 in increments of .01, and the likelihood function was very flat over this range. For both the ES and ESI models, the likelihood function generally increases in η and reaches a maximum at $\eta=.30$, though the absolute difference between the log likelihoods evaluated at $\eta=.15$ and $\eta=.30$ is less than .126. Since $\eta=.15$ provides a reasonable pattern of debt retirements, it is used in all of the reported estimates. Second, in the most general model with γ and σ entering freely, the data were not rich enough to permit direct and accurate estimates of these parameters. To avoid the large standard errors that occurred in some instances, we defined $\tilde{\sigma}=\gamma+\sigma$, obtained estimates of γ and $\tilde{\sigma}$, and calculated σ in terms of these directly estimated parameters. Estimates of the other model parameters remain largely unaffected under either estimation technique.

Additional estimates of (16) are presented in the following tables.

TABLE A-I

TWO OR THREE CAPITAL STOCKS*
DEPENDENT VARIABLE LAGGED TWICE
NONLINEAR LEAST SQUARES/FIML

Parameter or Statistic	Equipment + Structures (1)	Equipment + Structures (2)	Equipment + Structures (3)	Equipment + Structures + Inventory (4)	Equipment + Structures + Inventory (5)	Equipment + Structures + Inventory (6)
δ	.042	.043	.047	.081[a]	.083[a]	.095[a]
	(.032)	(.033)	(.032)	(.027)	(.028)	(.028)
α	217.259	200.072	227.480	87.866[b]	78.137[a]	83.900[a]
	(118.011)	(120.402)	(131.788)	(32.732)	(28.019)	(27.888)
γ	0.0	1.912	11.979	0.0	1.931	5.789
	---	(8.095)	(68.388)	---	(5.788)	(6.718)
$\tilde{\sigma}$	1.0	1.0	2.904	1.0	1.0	1.900
	---	---	(13.825)	---	---	(1.354)
σ	---	-.912	-9.075	---	-.931	-3.890
	---	(8.095)	(54.586)	---	(5.788)	(5.377)
ψ_1#	.851[a]	.853[a]	.858[a]	.381	.379	.381
	(.272)	(.270)	(.264)	(.192)	(.191)	(.195)
ψ_2#	-.176	-.187	-.217	-.164	-.173	-.267
	(.262)	(.258)	(.255)	(.210)	(.200)	(.209)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.468	.458	.455	.287	.297	.359
m	3.465[a]	4.014[a]	3.188[a]	3.509[a]	5.860[a]	5.126[a]
RSS	.224	.220	.213	.474	.451	.396
Log L	107.676	107.939	108.486	95.661	96.453	98.545

*See the notes at the foot of Table I.
#The subscript indicates the length of the lagged dependent variable.

TABLE A-II THREE CAPITAL STOCKS WITH A LIQUIDITY VARIABLE*

(ξ* LIQ(t)/K(t))

NONLINEAR LEAST SQUARES/FIML OR NONLINEAR INSTRUMENTAL VARIABLES

Parameter or Statistic	NLSQ/FIML			NLIV		
	(1)	(2)	(3)	(4)	(5)	(6)
δ	.035 (.022)	.037 (.032)	.039 (.022)	.033 (.028)	.034 (.032)	.034 (.033)
α	150.875 (98.585)	132.286 (111.220)	148.675 (85.025)	159.251 (140.310)	144.358 (121.231)	144.829 (132.824)
γ	0.0 ---	2.307 (12.060)	11.239 (24.381)	0.0 ---	1.997 (27.268)	2.010 (36.677)
$\tilde{\sigma}$	1.0 ---	1.0 ---	2.898 (4.933)	1.0 ---	1.0 ---	.990 (2.845)
σ	--- ---	-1.307 (12.060)	-8.341 (19.461)	--- ---	-.997 (27.268)	-1.020 (35.240)
ψ	.395[b] (.185)	.391 (.199)	.377 (.189)	.399# (.204)	.397 (.202)	.398 (.203)
ξ	.440[b] (.191)	.420 (.221)	.434[b] (.163)	.471# (.329)	.460 (.394)	.460 (.424)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.433	.421	.472	---	---	---
m	2.935[a]	3.260[a]	3.060[a]	3.029[a]	2.983[a]	3.180[a]
RSS	.377	.371	.326	.378	.372	.372
Log L	99.330	99.601	101.658	---	---	---

*See the notes at the foot of Tables I and II and fn. 23.
#These coefficients become statistically significant when the standard errors are computed from a linear instrumental variables computer routine.

TABLE A-III — THREE CAPITAL STOCKS WITH A DEMAND VARIABLE*

$(\xi * \dot{Y}(t)/Y(t))$

NONLINEAR LEAST SQUARES/FIML OR NONLINEAR INSTRUMENTAL VARIABLES

Parameter or Statistic	NLSQ/FIML (1)	NLSQ/FIML (2)	NLSQ/FIML (3)	NLIV (4)	NLIV (5)	NLIV (6)
δ	.011	.013	.016	-.052	-.054	-.052
	(.021)	(.023)	(.018)	(.038)	(.045)	(.044)
α	746.770	502.033	405.729	-93.721	-87.184	-99.206
	(2162.480)	(1088.370)	(605.755)	(78.091)	(73.788)	(104.604)
γ	0.0	1.740	3.988	0.0	1.836	.393
	---	(14.941)	(7.609)	---	(10.848)	(4.663)
$\tilde{\sigma}$	1.0	1.0	1.642	1.0	1.0	.844
	---	---	(1.265)	---	---	(1.093)
σ	---	-.740	-2.346	---	-.836	.451
	---	(14.941)	(6.403)	---	(10.848)	(5.055)
ψ	.814[a]	.804[a]	.786[a]	1.345[a]	1.354[a]	1.340[a]
	(.186)	(.181)	(.164)	(.341)	(.349)	(.347)
ξ	.281[a]	.276[a]	.268[a]	.599[a]	.607[a]	.595[a]
	(.061)	(.060)	(.058)	(.165)	(.172)	(.172)
η	---	.150	.150	---	.150	.150
$\bar{R}^2$	.701	.691	.687	---	---	---
m	.060	.084	.280	-.190	-.093	-.650
RSS	.199	.198	.193	.568	.582	.576
Log L	109.580	109.678	110.009	---	---	---

*See the notes at the foot of Tables I and II.