The Neoclassical Model of Corporate Investment Behavior Revisited

Authors	Donald L. Hooks, and Walter S. Misiolek
Working Paper Number	1981-003A
Creation Date	January 1981
Citable Link	https://doi.org/10.20955/wp.1981.003
Suggested Citation	Hooks, D.L., Misiolek, W.S., 1981; The Neoclassical Model of Corporate Investment Behavior Revisited, Federal Reserve Bank of St. Louis Working Paper 1981-003. URL https://doi.org/10.20955/wp.1981.003

The Neoclassical Model of Corporate Investment Behavior Revisited

Donald L. Hooks and Walter S. Misiolek*

Federal Reserve Bank of St. Louis

Research Paper 81-003

*Associate Professor and Assistant Professor of Economics, respectively, University of Alabama. This paper was completed while Donald Hooks was a Visiting Scholar at the Federal Reserve Bank of St. Louis during 1980-81. The authors gratefully acknowledge the research assistance of Thomas Noser and the support of a College of Commerce and Business Administration grant.

0947R
06/17/81
DH:byb

The Neoclassical Model of Corporate Investment Behavior Revisited

Donald L. Hooks and Walter W. Misiolek

I. INTRODUCTION

More than a decade has passed since Jorgenson and Siebert ([1968a], [1968b]) published their important time series studies of the investment behavior of individual corporations. Their investment functions, typical of the neoclassical approach, were formulated as stock adjustment models in which the desired or optimal capital stock was determined by the marginal product of capital, capital's user cost, and the prices of output and capital goods.[1/] Jorgenson and Siebert (hereafter J&S) were particularly interested in evaluating the possible effects of inflation and the tax structure on investment through their roles as determinants of the implicit rental price of capital. They concluded that their neoclassical model explained corporate investment behavior quite well in comparison with alternative models and that the inflation rate, albeit relatively low by current standards, was an important determinant of capital goods demand in the postwar period ending in 1963.

The purpose of this paper is to reexamine this neoclassical approach and to present new estimates of individual corporate investment functions for the U.S. Because the inflation rate has been higher and more variable recently than during the period studied by J&S, and in view of current discussions regarding changes in the tax structure and other incentives to stimulate investment, these new estimates should contribute additional evidence regarding the validity of the neoclassical approach to modeling the responsiveness of investment to changes in fiscal and monetary policy parameters.

In our attempts to update the estimates of J&S we encountered several problems with their particular specification of the investment function. First, their failure to specify the roles of raw materials and intermediate inputs in production results in ambiguities in the derivation of the marginal product of capital. To remedy this, we have considered alternative assumptions about the nature of the underlying production function. Second, because of problems associated with negative values of proxies for the real interest rate, we have had to specify an alternative investment function which, like that used by J&S, is consistent with neoclassical theory, but which does not require the specification of the optimal capital stock. Finally, current debates regarding the replacement cost versus historical cost accounting practices have led us to reconsider the construction of measures of the existing capital stock.

Our findings indicate that the work of J&S and other contemporary studies by Jorgenson and his collaborators ([1963], [April 1967], [June 1967]) may suffer from one or more specification errors which have been overlooked by even the most recent critics of the neoclassical model, and which could bias the results of tax policy simulations and comparisons with alternative investment functions as reported by Jorgenson and Siebert.[2/]

II. The Marginal Product of Capital

Following J&S, we assume that the production function has as its arguments capital (K) and labor (L), that it is Cobb-Douglas in form, that it exhibits constant returns to scale, and that output and input prices are parametrically given by competitive markets. Although the validity of most elements of this set of conventional neoclassical assumptions has been debated, little attention has been paid to the implications of the two-factor production function in this context. In order to explore the possible implications of this assumption, we posit a third set of factors, material inputs, which includes all other inputs such as natural resources and intermediate goods; furthermore, we assume these factors enter the production process in fixed proportions to each other, which enables us to aggregate them into a single factor M. This class of inputs has been omitted from most specifications of production functions to be found in the literature; yet, even the most cursory examination of many production processes suggests they do indeed make up a significant share of total cost.[3/]

If the true production process is described in general as $Q = f(K, L, M)$, one of several explicit assumptions regarding functional form is necessary to ensure that the marginal product of K can be derived. Two alternatives permit derivation of results similar to those of J&S: (1) separability of M from K and L, and (2) assumption of an extended three-factor Cobb-Douglas function exhibiting constant returns to scale. We will consider derivations of the optimum capital stock under each of these assumptions and examine the implications for estimation of the investment function in each case.

The first alternative suggests M is separable if it enters the production process in fixed proportion to output.[4/] This can be expressed as

(1) $$Q = \text{Min}\left(\frac{M}{\mu}, T\right),$$

where $\mu = M/Q$ is interpreted as the materials requirement ratio and T is the transformation activity of capital and labor expressed in units of final product transformed. To retain consistency with Jorgenson's work, we assume that the transformation function is of Cobb-Douglas form and exhibits constant returns to scale. Thus we have

(2) $$T = AK^{\alpha}L^{1-\alpha}$$

and Euler's theorem can be invoked to obtain the usual factor demand functions. In order to define the marginal product of capital, we follow Frisch [1965] in treating M as a "shadow factor" of T; i.e., we assume K and L will not be applied if sufficient material inputs are not available. The marginal product of capital is then defined in terms of the transformation function as

(3) $$MP_K = \frac{\partial T}{\partial K} = \frac{\alpha T}{K}$$

and the marginal revenue product is

$$(4) \qquad \rho = \frac{\alpha \eta T}{K},$$

where η is the value added per unit of transformed product and ρ is the return to capital. This is equivalent to writing

$$(5) \qquad \rho = \frac{\alpha(pQ - mM)}{K},$$

where p and m are the prices per unit of output and materials, respectively. If M has erroneously been omitted from the production function, it is clear that the resultant expression

$$(6) \qquad \rho = \frac{\alpha(pQ)}{K}$$

will overstate the return to capital in proportion to the degree to which sales revenues (pQ) exceed net value added to materials (pQ - mM).

If we assume the second alternative of a three-factor Cobb-Douglas function exhibiting constant returns to scale

$$(7) \qquad Q = AK^{\alpha}L^{\beta}M^{\gamma}, \qquad \alpha + \beta + \gamma = 1$$

the marginal product of capital is

$$(8) \qquad \frac{\partial Q}{\partial K} = \frac{\alpha Q}{K}.$$

Assuming competitive markets, we can obtain an expression for the marginal revenue product of capital which is identical to

$$(9) \qquad \rho = \frac{\alpha(pQ)}{K},$$

the J&S equation derived from a two-factor production function.

Jorgenson [1972] vigorously defends this specification of the return to capital in a recent survey of the empirical literature on production functions in which he argues that the weight of the evidence supports his maintained assumptions of: (1) constant elasticity of substitution ≈ 1 (Cobb-Douglas form), and (2) constant returns to scale. Unfortunately, the evidence cited is based on estimates of two-factor production functions. If equation (7) represents the appropriate form of the production function, and if we accept Jorgenson's contention that $\alpha + \beta = 1$, then $\alpha + \beta + \gamma$ must exceed unity. Euler's theorem does not hold in this case and equation (9) cannot be interpreted (is not derivable) as an input demand function because payments to the three factors according to the value of their marginal product would more than exhaust the value of output. Although it could be argued that the factors could be paid less than, but still in proportion to, their marginal revenue products, this would be inconsistent with the maintained assumption of competitive factor market equilibrium. Given his initial assumptions, therefore, Jorgenson's [1972] interpretation of the empirical evidence on returns to scale for two inputs appears to require the assumption of separability (fixed proportions) of material inputs in the production function to allow derivation of the optimal capital stock. There appears to be no conlcusive support in the literature for selecting one specification over the other.[5/] In our empirical work, therefore, we estimated investment functions consistent with each.

III. The User Cost of Capital

The two forms of the neoclassical investment function estimated by J&S differed in the way capital gains (price expectations) were treated. If capital gains can be assumed to be transitory, they may be ignored in determining the cost of capital, c, in the neoclassical model. Otherwise, c should include some measure of expected rates of change of the price of business investment goods. J&S calculated the user cost of capital as

$$(10) \qquad c = \frac{q}{1-\tau}\left[(1-\tau w)\,\delta + r - \dot{q}\right],$$

where q is the investment goods price index, is the corporate tax rate, δ is the depreciation rate, r is the discount rate, w is the proportion of depreciation that is tax deductible, and $\dot{q}$ denotes the rate of change of the price of investment goods (J&S Model I).

In this study, however, we utilize the measure of user cost suggested by Sumner (1973)

$$(11) \qquad c = \frac{q}{1-\tau}\left[(r + \delta - \dot{q})\,(1 - k - \tau A)\right],$$

where k is the investment tax credit rate and A is the present value, discounted at rate r, of depreciation deductions on an investment of $1.00. The other variables are as defined in equation (10). In addition to allowing for investment tax credits available intermittently since 1961, this specification avoids the assumption that the required rate of return i is a constant, where

$$(12) \qquad r = i(1 - \tau).$$

Moreover, we assume that depreciation for tax purposes is equal to economic depreciation; thus

(13) $A = \frac{\delta}{\delta+r}$.

IV. The Investment Function

Jorgenson and Siebert calculated the optimal capital stock, K*, by equating their measure of capital's marginal revenue product with the user cost of capital.6/ The resulting expression,

(14) $K^* = \frac{\alpha pQ}{c}$

was then entered as an explanatory variable in their investment function. Unfortunately, we found that the use of plausible measures of $\dot{q}$ tended to result in very small and even negative values of c in some cases; thus, the calculated values of K* included as a variable in the investment function became implausibly large or negative during the inflationary period over which our estimates were made. Moreover, even when $\dot{q}$ was omitted from c, our attempts to estimate investment functions of the type specified by J&S (see footnote 8 below) resulted in implausible parameter estimates and very poor fits to the data.

To avoid the absurd outcome associated with a negative desired capital stock, we adopted an alternative form of the investment function consistent with the neoclassical approach

(15) $\frac{\Delta K}{K} = \lambda\ (\rho - c) + \delta$,

where ΔK is the change in the real capital stock.7/ This specification reflects the assumption that new capital investment takes place until its rate of return equals its user cost and allows for positive investment even in the event c becomes negative.

Alternative measures of real output were used in the calculation of ρ consistent with the alternative production functions discussed in the previous section. Under the assumption that M enters the production process in fixed proportion to output, ρ is appropriately defined as

$$(16) \qquad \rho = \frac{\alpha(pQ-mM)}{K},$$

where (pQ-mM) is value added by capital and labor (VA). If M is assumed to enter as a third variable factor in an extended Cobb-Douglas production function, ρ is defined as

$$(17) \qquad \rho = \frac{\alpha(pQ)}{K},$$

where pQ is sales revenues (Y).

The gross investment function is obtained by rewriting (15) as

$$(18) \qquad I = \Delta K = \lambda\ (\rho - c)\ K + \delta K$$

and the net investment function is

$$(19) \qquad I^n = \Delta K - \delta K = \lambda\ (\rho - c)K.$$

If there are lags in the delivery of equipment and costs of adjustment are nonzero, current net investment becomes a function of current and lagged differences between ρ and c. Assuming a geometric lag is appropriate for modeling this specification, we obtain

$$(20) \qquad I^n_t = \gamma\lambda\ (\rho - c)_t K_t + \gamma^2\lambda\ (\rho-c)_{t-1}K_{t-1} + \ldots.$$

The Koyck transformation yields

$$(21) \qquad I^n_t = \gamma\lambda(\rho-c)_t K_t - \gamma I^n_{t-1}.$$

Substituting (16) and (17) for ρ with the definitions of VA and Y incorporated as appropriate, we obtain the two general forms of the neoclassical model estimated in this study[8/]

(22) $I_t^n = b_o + b_1 VA_t + b_2 (cK)_t + b_3 I_{t-1}^n + \varepsilon_t$

(23) $I_t^n = b_o + b_1 Y_t + b_2 (cK)_t + b_3 I_{t-1}^n + \varepsilon_t$,

where cK is defined as capital costs.[9/]

We also followed J&S in estimating several alternative non-neoclassical investment functions for comparison purposes: the accelerator, the liquidity and the expected profit models. Experimentation with these models revealed that a variant of the liquidity model tested by J&S clearly dominated other non-neoclassical specifications for five of the six industry groups. This simple liquidity model can be written

(24) $I_t^n = b_o + b_1 F_t + \varepsilon_t$,

where F is the real value of internal funds available for investment (after-tax profits plus depreciation allowances less dividends). If delivery lags are present, this form may be written

(25) $I_t^n = b_o + b_1 I_t + b_2 F_{t-1} + \varepsilon_t$.

In some cases we found that allowing for lags improved the fit of this form significantly, while in others little improvement was observed.

In addition, a variant of the J&S expected profits model, which assumes profits are proportional to the market value of the firm (market value of equity plus book value of debt), was estimated. The form used was

$$(26) \qquad I_t^n + b_o + b_1 V_t + b_2 V_{t-1} + \epsilon_t,$$

where V is the firm's market value.

IV. Estimation of the Models

A. The Data

We have followed J&S in selecting the largest firms for which suitable time series data exist, but have included three firms in each of six industry groups to allow us to determine whether similar patterns exist over time across industries as well as across firms within industries. The eighteen firms and their industry groups are listed in Table 1, along with several indicators of their relative sizes and growth rates.

The replacement value of the capital stock (K) was calculated according to the method suggested by Davidson and Weil [1975]. The average ages of plant and equipment for year one (1958) was estimated by dividing accumulated depreciation by annual depreciation charges. This method assumes straight line depreciation was practiced by each firm, which is consistent with the development of equation (14) above. The book value of each firm's capital stock in 1958, which was taken from the Compustat Industrial File, was divided by the price index for fixed business investment for the year corresponding to the average age of the firm's capital; e.g., 1951 if the estimated average age was 7 years. Constant dollar gross investment less economic depreciation was then added for each year to accumulate capital through time.

The depreciation rates, which were intended to represent economic rather than accounting rates, were obtained from Value Line. They are firm specific in all but three cases.[10/] The remaining variables used in estimating the neoclassical model included output (either total sales or value added by capital and labor), the user cost of capital services, and lagged investment. Total sales (Y) and value added (VA) were taken from the Compustat Industrial File and were converted to constant dollars using the price index appropriate for each industry group. Although J&S added total inventories to total sales, we did not because output conceptually should include finished goods inventories only. The latter were not available for most of our sample firms for the entire period. Data on changes in total inventories were available, but they were predominantly input inventories; moreover, finished goods and input inventories frequently moved in opposite directions when both were reported.

The user cost of capital services (c), which was calculated by the method suggested by Sumner (1973), utilized the AAA bond rate (r), corporate tax rates (τ, k), firm specific economic depreciation rates (δ), and the GNP deflator for fixed business investment (q). A number of alternative measures of capital goods price expectations ($\dot{q}$) were used, and the best results were obtained by assuming long term expectations could be explained by fitting a geometric function to the historical price index series. Short term expectation proxies performed poorly. The market value of the firm (V) and liquidity (F) were constructed from Compustat file data.

B. Empirical Results

Table 2 presents estimates of the neoclassical model with capital gains and the two output measures for each firm for 1958-77. Note that the value added measure results in a better fit in thirteen of the eighteen cases, which can be interpreted as evidence supporting the separable form of the production function. In both the oil and chemical industries, however, sales revenues outperformed value added for two of the three firms. This evidence indicates that different assumptions regarding the nature of the productive process may be appropriate for different industries or even for different firms within industries, which raises serious questions concerning the validity of conclusions drawn from studies of aggregate investment behavior.

In fifteen cases, the capital cost (cK) coefficient was larger when total sales rather than value added was used as a measure of output. This suggests that if the true model specifies value added as the measure of output, the use of total sales results in a bias in the estimate of the capital cost coefficient. Thus, any simulations of tax changes based on such estimates will result in an overstatement of their effects on business investment.[11/]

The best estimates of the alternative non-neoclassical models are presented in Tables 3 and 4. Note that the liquidity model fit the data better that the neoclassical model in a number of cases. For firms of the auto and steel industries the fit of the liquidity model improved substantially when the value of internal funds lagged one period was included in the estimating equation. This is reflected in the uniformly low t-statistics for the liquidity measure as compared with lagged liquidity reported in Table 3 for these firms. For the remaining four industries including lagged liquidity generally resulted in little or no improvement in fit.

Estimates of the expected profits or market value model are presented in Table 4 only for the firms of the auto industry, the only industry in which that model performed best in terms of goodness of fit.[12/] It should be noted that specifications of the liquidity and profit model estimates presented in these tables differ from those reported by J&S, who regressed I on the change rather than on the level of F or V. Our experiments with first differences produced estimates that were inferior to those reported in Tables 3 and 4.[13/] Thus, it appears that the superiority of the J&S neoclassical models may have been due in part to their particular specification of the non-neoclassical models.

Experiments with dummy variables to capture the effects of investment decisions that may have been mandated by environmental regulations were unsuccessful. Still, it is possible that the estimates reported in Table 2 fail to explain all investment in part because of "noneconomic" decisions forced upon the firms for environmental reasons. The data on pollution control equipment as a percent of total plant and equipment investment for the industry groups used in this study (Table 5) give some indication of the potential magnitude of the problem.

VI. Conclusions

The purpose of this study was to reexamine and update the work of Jorgenson and Siebert on the estimation of neoclassical investment functions. In so doing, we found it necessary to reformulate the neoclassical model to allow estimation during periods in which the estimated real user cost of capital may be zero or even negative. Like J&S, we conclude that the empirical comparisons indicate that the neoclassical model had a better fit for the majority of the firms and a majority of the industries examined. The liquidity model outperformed the neoclassical for two of the three firms in the petroleum and paper industries and the expected profits model outperformed the neoclassical for two of the three firms in the auto industry.

Our estimates of alternative forms of the neoclassical model revealed that the magnitudes of the estimated coefficients are very sensitive to assumptions concerning the nature of the underlying production functions and that different production functions appear appropriate for different firms. Misspecification of the production process could lead to the erroneous rejection of the neoclassical model in some cases and to biases in simulations of tax and monetary policy effects in others. To the extent that our results can be generalized, it appears that we have maintained empirical support for the neoclassical approach in a highly inflationary environment, but have raised some doubts concerning whether or not it is appropriate to aggregate across firms or across industries in modeling corporate investment behavior.

REFERENCES

A. R. Bergstrom, The Construction and Use of Economic Models (London· The English Universities Press, 1967).

E. R. Berndt and D. O. Wood, "Technology, Prices and the Derived Demand for Energy," The Review of Economics and Statistics, (August 1975), pp. 259-268.

S. Davidson and R. L. Weil, "Inflation Accounting: What Will General Price Level Adjusted Income Statements Show?" Financial Analysts Journal (January/February 1975), pp. 27-31 and 70-84.

R. Eisner, "Econometric Studies of Investment Behavior: A Comment," Journal of Economic Literature (March 1974 b), pp. 49-50.

______________, "Issues in Economic Studies of Investment Behavior: Comment," Journal of Economic Literature (March 1974 b), pp. 49-50.

A. Falkenstein and R. L. Weil, "Replacement Cost Accounting: What Will Income Statements Based on the SEC Disclosures Show?" Financial Analysts Journal (January/February 1977 and March/April 1977), pp. 46-57 and 48-57.

R. Frisch, Theory of Production (Chicago: Rand McNally, 1965).

R. E. Hall and D. W. Jorgenson, "Tax Policy and Investment Behavior," American Economic Review (June 1967), pp. 391-414.

D. B. Humphrey and J.R. Moroney, "Substitution Among Capital, Labor and Natural Resource Products in American Manufacturing," Journal of Political Economy (February 1975), pp. 57-82.

D. W. Jorgenson, "Capital Theory and Investment Behavior," American Economic Review (May 1968), pp. 247-259.

______________, "Econometric Studies of Investment Behavior: A Survey." Journal of Economic Literature (December 1971), pp. 1111-47.

______________, "Investment Behavior and the Production Function," Bell Journal of Economics (Spring 1972), pp. 220-251.

D. W. Jorgenson and C. D. Siebert, "A Comparison of Alternative Theories of Corporate Investment Behavior," American Economic Review (September 1968), pp. 681-712.

________________, "Optimal Capital Accumulation and Corporate Investment Behavior," Journal of Political Economy (November/December 1968), pp. 1123-51.

L. R. Klein, "Issues in Econometric Studies of Intestment Behavior," Journal of Economic Literature (March 1974), pp. 43-49.

D. J. Ott, A. F. Ott, and J. H. Yoo, Macroeconomic Theory (New York: McGraw Hill, 1975).

M.T. Sumner, "Investment and Corporate Taxation," Journal of Political Economy (July/August 1973), pp. 982-93.

FOOTNOTES

1/ See also Jorgenson [1963], and Hall and Jorgenson [1967].

2/ A number of questions regarding the neoclassical approach as best typified by Jorgenson's work are raised by Eisner [1974 a,b] and Klein [1974], among others.

3/ For example, Humphrey and Moroney [1974, p. 67] report that natural resources alone account for as much as 37 percent of costs in some U.S. manufacturing industries and Berndt and Wood [1975] estimate the cost share of energy and intermediate materials at approximately 65 percent for U.S. manufacturing as a whole.

4/ See Humphrey and Moroney [1975] and Berndt and Wood [1975] for further discussion of theoretical and empirical issues related to the question of factor separability.

5/ Humphrey and Moroney [1975] report that the three factor Cobb-Douglas form does not appear appropriate although some factor substitution is indicated. Berndt and Wood [1975] rejected the fixed proportions specification.

6/ For a formal derivation of Equation (9) from a profit maximizing model see Ott, Ott, and Yoo [1975].

7/ Bergstrom [1967] assumed a similar investment function, although he specified it in logarithmic form.

8/ Note that J&S estimated (with varying lag lengths) $I_t = b_o + b_1 (K_t^* - K_{t-1}^*) + b_2 (I_{t-1} - \delta K_{t-1}) + b_3 (\delta K)_{t-1} + \epsilon_t$, where K* is calculated from equation (11) with and without q. Note, too, that Jorgenson and Siebert employ sales revenues, whereas Hall and Jorgenson [1967] use value added data to measure output. In his survey of econometric investment studies, Jorgenson [1971] states that "gross value added" data were used in estimating K* in the Jorgenson and Siebert papers, whereas in the papers themselves it is stated that output was measured by sales plus the change in inventories, which results in further confusion on this matter.

9/ Although this specification allows for negative ex ante flows (ck) when c is negative, this appears to be more plausible than a negative desired capital stock (K*).

10/ Industry average rates were used for Chrysler, Monsanto, and International Paper due to discrepancies between these capital stock estimates and those obtained by the method suggested by Falkenstein and Weil [1977].

11/ Klein [1974] believed the simulations in Hall and Jorgenson [1967] produced implausibly large investment responses to tax changes, but he attributed this to their specification of the cost of capital.

12/ The results for the accelerator model are not presented here because they were never better than the liquidity model estimates.

13/ This supports our view that the desired level of investment and not the desired capital stock is determined by these financial variables.

TABLE 1

Firms Selected for Analysis

Firms and Industry	Average Capital Stock	Average Gross Investment	Average Net Investment
Automobiles			
General Motors	8035.2	811.9	378.0
Ford	4511.9	456.4	190.2
Chrysler	1489.7	162.4	80.4
Steel			
United States Steel	7346.5	427.7	185.2
Bethlehem Steel	2977.1	260.2	114.3
Republic Steel	1688.4	98.9	43.1
Chemicals			
Dupont	2857.3	292.2	180.8
Dow	1819.7	290.0	162.6
Monsanto	1433.4	201.8	98.6
Petroleum			
Exxon	14206.5	1438.0	756.1
Texaco	6119.2	721.1	390.7
Gulf	6477.8	694.9	358.1
Rubber			
Goodyear	1383.7	160.6	92.8
B. F. Goodrich	634.6	66.6	35.5
Uniroyal	665.9	60.5	27.2
Paper			
International Paper	1497.3	151.9	84.5
St. Regis Paper	589.3	51.8	24.7
Union Camp	379.3	39.3	23.0

Mean annual estimates for 1958-1977 in millions of 1967 dollars.
Source: Compustat Annual Industrial Data File.

TABLE 2

Estimates of the Neoclassical Model

Firms	Value Added	Total Sales	Capital Cost	Lagged Investment	Constant	F	D.W.	R^2
General Motors	0.35 (1.69)		-.247 (1.89)	.584 (3.27)	74.0 (-0.43)	5.24	1.71	.50
		.016 (1.51)	-.262 (1.79)	.611 (3.35)	91.7 (0.53)	4.92	1.66	.48
Ford	.078 (4.34)		-.493 (4.02)	.658 (4.83)	-70.3 (0.11)	12.42	1.78	.70
		.029 (3.61)	-.538 (3.51)	.610 (4.13)	39.1 (0.59)	9.47	1.42	.64
Chrysler	.116 (3.35)		-.816 (3.42)	.476 (2.97)	-13.9 (0.31)	7.92	2.32	.60
		0.34 (2.80)	-.916 (3.01)	.579 (3.39)	10.3 (0.23)	6.26	2.08	.54
United States Steel	.114 (1.26)		-.065 (0.59)	.667 (4.01)	-176.0 (0.74)	5.46	1.50	.51
		.062 (1.07)	-.143 (1.08)	.730 (3.83)	-115.1 (0.52)	5.19	1.73	.49
Bethlehem Steel	.262 (1.79)		-.218 (1.14)	.406 (1.93)	-234.3 (1.23)	3.16	1.83	.37
		.203 (2.42)	-.387 (1.88)	.457 (2.39)	-312.3 (1.78)	4.33	1.97	.45
Republic Steel	.247 (2.28)		-.190 (1.11)	.470 (2.75)	-95.7 (1.39)	4.69	1.41	.47
		.126 (2.11)	-.298 (1.61)	.574 (3.22)	-92.1 (1.28)	4.33	1.56	.45

TABLE 2 (Continued)

Firms	Value Added	Total Sales	Capital Cost	Lagged Investment	Constant	F	D.W.	R^2
Goodyear	.134 (3.03)		-.490 (3.27)	.760 (5.16)	-38.3 (1.49)	16.76	2.00	.76
		.049 (2.36)	-.514 (2.63)	.890 (5.78)	-33.6 (1.13)	13.60	2.08	.72
B. F. Goodrich	.213 (3.56)		-.618 (3.77)	.710 (4.28)	-40.4 (2.00)	8.77	2.22	.62
		.119 (3.22)	-.761 (3.50)	.853 (4.53)	-61.5 (2.19)	7.64	2.30	.59
Uniroyal	.168 (3.57)		-.563 (3.92)	.490 (3.34)	-34.8 (2.05)	12.50	2.25	.70
		.075 (3.36)	-.625 (3.74)	.574 (3.98)	-34.9 (1.94)	11.60	2.11	.68
Exxon	.096 (2.02)		-.073 (0.65)	.741 (3.26)	38.9 (0.24)	7.82	1.76	.59
		.046 (2.47)	-.105 (0.97)	.402 (2.15)	-18.6 (0.12)	9.15	1.68	.63
Texaco	.390 (3.73)		-4.70 (3.00)	.370 (1.92)	-24.5 (0.24)	6.76	2.38	.56
		-.001 (0.08)	.032 (0.22)	.433 (1.63)	203.3 (.176)	1.13	1.75	.18
Gulf	.072 (0.42)		-1.46 (0.48)	.432 (1.30)	199.8 (1.11)	0.58	1.41	.10
		.078 (1.85)	-.304 (1.56)	.627 (2.01)	19.3 (0.11)	1.77	1.50	.25
International Paper	3.22 (1.81)		-4.51 (1.34)	.421 (1.97)	-90.2 (1.21)	3.15	1.90	.37
		.123 (1.51)	-.464 (1.17)	.460 (2.10)	-58.8 (0.86)	2.71	1.87	.34

TABLE 2 (Continued)

Firms	Value Added	Total Sales	Capital Cost	Lagged Investment	Constant	F	D.W.	R^2
St. Regis Paper	.175 (1.64)		-.482 (1.81)	.510 (2.59)	-9.6 (0.45)	3.58	1.53	.40
		.067 (1.63)	-.469 (1.81)	.510 (2.59)	-5.4 (0.28)	3.57	1.45	.40
Union Camp	.336 (1.84)		-.606 (1.30)	.448 (1.73)	-15.8 (0.94)	2.06	1.85	.29
		.089 (1.25)	-.410 (0.81)	.416 (1.51)	-0.8 (0.06)	1.36	1.77	.21
Dupont	.082 (0.87)		-.132 (0.66)	.471 (1.89)	011.5 (0.09)	1.35	1.60	.21
		.044 (0.84)	-.169 (0.70)	.394 (1.57)	31.6 (0.33)	1.37	1.46	.20
Dow	.351 (3.59)		-.472 (1.58)	.425 (2.45)	-77.4 (2.17)	22.66	1.84	.81
		.169 (4.00)	-.507 (1.81)	.355 (2.14)	-53.0 (1.69)	25.09	1.79	.82
Monsanto	.120 (0.88)		-.319 (0.93)	.498 (2.31)	30.3 (0.66)	3.01	1.60	.36
		.068 (1.03)	-.400 (1.07)	.480 (2.22)	26.9 (0.59)	3.15	1.65	.37

Note: Estimates are for 1958-1977. Values in parentheses are t-statistics.

TABLE 3

Estimates of the Liquidity Model

Firm	Constant	Liquidity Measure	Liquidity Lagged	F	D.W.	R^2
General Motors	358.1 (1.44)	.12 (0.66)	.35 (2.04)	2.48	1.23	.24
Ford	48.6 (0.46)	.13 (1.00)	.60 (4.42)	11.2	.77	.58
Chrysler	7.7 (0.23)	.26 (1.67)	.65 (4.30)	15.8	1.56	.66
United States Steel	325.9 (3.04)	-.49 (1.84)	.74 (2.47)	3.3	1.43	.29
Bethlehem Steel	4.6 (0.08)	.08 (0.42)	1.15 (3.93)	11.8	1.94	.60
Republic Steel	24.3 (0.82)	-.10 (0.26)	1.04 (2.63)	5.01	1.39	.39
Goodyear	-72.7 (2.68)	1.52 (9.04)		81.7	1.68	.83
B. F. Goodrich	22.8 (1.23)	.85 (2.54)		6.4	.96	.27
Uniroyal	-7.78 (0.48)	1.36 (4.37)		19.1	1.17	.53
Exxon	360.3 (1.88)	.79 (6.09)		37.1	.88	.69
Gulf	-41.0 (0.18)	1.17 (3.40)		11.5	1.00	.40
Texaco	-57.2 (0.50)	1.10 (7.07)		49.9	1.62	.75

TABLE 3 (Continued)

Firm	Constant	Liquidity Measure	Liquidity Lagged	F	D.W.	R^2
International Paper	-10.0 (0.27)	1.25 (4.65)		21.7	1.31	.56
St. Regis Paper	24.4 (1.33)	.57 (1.67)		.78	.99	.14
Union Camp	4.03 (0.38)	.03 (3.61)		13.1	1.39	.45
Dupont	317.4 (6.49)	.27 (2.06)		4.2	.83	.20
Dow	-28.1 (0.91)	1.28 (12.0)		143.6	.95	.89
Monsanto	20.9 (0.31)	.96 (2.86)		8.19	1.16	.33

Note: Estimates are for 1958-1977. Values in parentheses are t-statistics.

TABLE 4

Estimates of the Expected Profits Model

	Constant	Market Value	Market Value Lagged	Capital Stock	F	D.W.	R^2
General Motors	-174.23 (0.69)	.002 (0.24)	.029 (3.10)	.054 (2.94)	7.3	1.66	.59
	-16.1 (0.05)	.022 (2.52)		.055 (2.41)	4.0	1.67	.33
Ford	-281.7 (1.05)	.007 (0.27)	.065 (2.85)	.086 (2.86)	4.5	1.43	.47
	64.3 (0.22)	.023 (0.73)		.064 (1.84)	1.9	.88	.19
Chrysler	-12.3 (0.24)	.005 (0.17)	.102 (3.87)	.030 (1.16)	11.7	1.58	.70
	-15.3 (0.22)	.080 (3.14)		.054 (1.59)	5.4	1.98	.40

Note: Estimates are for 1958-1977. Values in parentheses are t-statistics.

TABLE 5

Pollution Control Equipment as a Percent of Total Fixed Business Investment

Industry	1974	1975	1976	1977	1978
Steel	12.1	13.5	15.1	16.7	19.5
Automobile	4.1	3.9	3.6	3.5	4.7
Paper	19.3	16.8	14.7	13.8	9.6
Chemicals	8.3	10.9	11.4	10.2	9.2
Petroleum	10.1	11.8	10.9	8.2	7.0
Rubber	3.2	4.0	3.4	3.3	3.0

Source: Council on Environmental Quality, Environmental Quality: The Ninth Annual Report of the Council on Environmental Quality, December 1978, U.S. Government Printing Office, pp. 422-23.