PETER K. CLARK
Stanford University

Investment in the 1970s: Theory, Performance, and Prediction

ONE of the most widely perceived characteristics of economic recovery since early 1975 has been the relatively slow growth of business fixed investment. At the end of 1978, for example, real GNP was 13.8 percent above the value attained at the cyclical peak five years earlier. By contrast, the performance of real nonresidential fixed investment has been poor. Its previous peak value, reached in the first quarter of 1974, was only surpassed in the second quarter of 1978. Even by the end of 1978, it was only 8.1 percent above the earlier peak.

During the past five years, the apparent sluggishness of nonresidential fixed investment has generated pronouncements about the declining incentive to invest and warnings that investment performance must be improved to maintain the growth of real income and of the supply capacity needed to reduce inflationary pressure. For example, in a widely publicized speech in October 1977, Arthur Burns examined business fixed investment and found: "In the two-and-a-half years of this expansion, real capital outlays have increased only half as much as they did, on average, over like periods in the five previous expansions. The shortfall

Note: I gratefully acknowledge comments by Roger E. Brinner and William D. Nordhaus and the research assistance of Martha M. Parry during the early stages of my work on investment. I especially thank Data Resources, Inc., for providing access to its forecast simulations, and Stephen H. Brooks for contributing guidance and assistance with the software.

0007-2303/79/0001-0073$00.25/0 © Brookings Institution

has been especially marked in the case of major long-lived industrial construction projects."[1]

The outgoing Republican administration's Council of Economic Advisers stated in its report of January 1977: "The growth of nonresidential fixed investment in 1976, especially in the latter part of the year, was low for this stage of the recovery."[2] The new Democratic administration's Council was still worried about fixed investment in January 1978: "It appears, however, that total investment outlays during the expansion have fallen somewhat short of those implied by historical relationships of investment to its determinants."[3] Because business investment plays an important role both in the determination of current aggregate demand and future growth of real income, it is appropriate that this perceived "low investment" be analyzed in an explicitly quantitative way, using econometric techniques. Much of this paper is devoted to just such an econometric analysis; it combines data on investment, output, capital stock, and prices with existing theories of investment behavior to provide a quantitative review of the performance of nonresidential fixed investment since 1973, and the possibilities for improving this performance in 1979 and beyond.

Four Questions about Investment Behavior

While the econometric evidence is being discussed, the reader should focus on the following four questions, which the analysis is designed to answer.

To what extent can the steep 1974–75 drop and subsequent slow recovery of nonresidential fixed investment be explained by the standard theories of business investment?

To answer this question, the actual path of investment since 1973 is compared with the path forecasted by several econometric models. These comparisons serve three purposes.

First, if the best available models consistently underpredict or over-

1. Arthur F. Burns, "The Need for Better Profits," address at Gonzaga University, Spokane, Washington, October 26, 1977, p. 3.
2. *Economic Report of the President, January 1977,* p. 37.
3. *Economic Report of the President, January 1978,* pp. 70–71.

predict since 1973, it could indicate either a change in behavior or the existence of additional determinants of investment that have been ignored because they remained relatively constant before 1973. For example, if increased regulation since 1973 has significantly lowered the rate of return on nonresidential capital, this reduction should show up as a negative differential between actual and predicted investment.

Second, a comparison of the predictions of various econometric models for the five-year period from 1973 to 1978 provides a good "specification test," especially because that interval includes substantial variation in investment, output, and other relevant variables. If some of the models predict well, the policy prescriptions derived from them should be given more weight than the policy conclusions based on models that have little predictive power.

Third, post-sample prediction over a five-year period allows a good test of the hypothesis that a considerable amount of "post-data model construction" has been used in the formulation of the econometric models of investment now in use. If "data mining" is an important problem, prediction errors outside the sample period should be significantly larger than within-sample estimation residuals.

Which models or variables best explain the behavior of business fixed investment? In particular, how important are interest rates and other capital cost considerations?

This question is central to the analysis of investment; if investment reacts to the rental price of capital services in the short run, then direct investment incentives, such as the investment tax credit or accelerated depreciation, may be appropriate tools for shifting aggregate demand. In addition, the effect of market interest rates on investment demand becomes an important consideration in the design of policy.

If output is the primary determinant of business fixed investment in the short run, then the pro-cyclical nature of investment is the most important consideration in policy design. Only the long-run effects of tax incentives for investment need to be considered, and short-run variations in interest rates are not as crucial.

What policies are likely to be most effective in maintaining or increasing the share of nonresidential fixed investment in total output over the next few years?

One of the most disturbing characteristics of the U.S. economy in the

1970s has been sluggish performance of productivity growth. Between 1948 and 1965, labor productivity in the nonfarm business sector grew almost 3 percent a year. Between 1965 and 1973, this figure dropped to about 2 percent a year. And between 1973 and 1978, productivity growth slowed further to only 1 percent a year. While reliable estimates are not yet available of the effect of nonresidential capital accumulation on productivity growth since 1973, most economists familiar with the data attribute a substantial role to slow growth in the capital stock. If the accumulation of fixed capital is an important determinant of productivity growth, policies designed to increase the share of output devoted to business fixed investment become more important.

What are the investment prospects for 1979–81?

Once the econometric models of investment demand have been estimated for the 1954–78 period, they can be used to project nonresidential fixed investment for the next three years. Various assumptions about the paths of output, interest rates, and the stock market can be tested to determine their effect on the future capital stock and the investment component of aggregate demand.

The purpose of this paper is to obtain quantitative answers to these four questions. First, five models of business investment behavior are developed analytically. These models roughly span the considerable range of disagreement among economists about the determinants of investment in fixed capital.[4] Next, the models are estimated for equipment and structures for the period from 1954 to mid-1973. Following a discussion of the estimates, they are used to project investment in equipment and structures from 1973:3 to 1978:4. These projections provide quantitative answers to the first three questions above. To investigate further some puzzling aspects of the results for the recent period, the behavior of various components of structures and equipment is analyzed. Finally, forecasting equations derived from the 1954–78 period are used to assess the prospects for business fixed investment through 1981.

4. By using a number of models, the problem of "model dependence" in the analysis is reduced. The reader can see how his favorite model explains the data and compare the results with those from competing models. This multimodel approach has been used previously by Bischoff and Kopcke. See Charles W. Bischoff, "Business Investment in the 1970s: A Comparison of Models," *BPEA, 1:1971*, pp. 13–58; and Richard W. Kopcke, "The Behavior of Investment Spending during the Recession and Recovery, 1973–76," *New England Economic Review* (November–December 1977), pp. 5–41.

The Models of Business Fixed Investment

Five models of business fixed investment are discussed below: accelerator, cash flow combined with accelerator, neoclassical, modified neoclassical, and securities value. These models are almost identical to the ones studied by Bischoff, except that his simple cash flow model has been replaced by one that includes an accelerator term.[5] No serious investigator of U.S. investment behavior has proposed a model that is based on cash flow alone. These five models are each applied to two components of real nonresidential fixed investment: expenditures on producers' durable equipment and expenditures on structures.[6]

GENERALIZED ACCELERATOR MODEL

Models of the accelerator type relating investment in fixed capital to changes in output have their origins in work by J. M. Clark early in this century[7] and later modifications by a number of economists, particularly Koyck and Chenery.[8] Such models generally take the empirical form of a linear relation of current net investment to current and past changes in output. The basic assumption of any accelerator model is that the desired capital stock at any point in time is a constant multiple of output, Y, at that time. That is,

$$K^d = \alpha Y, \tag{1}$$

where K^d is the "desired" capital stock, or the capital stock that would be chosen by entrepreneurs if net additions to capital were instantaneously available at a constant price.

If the capital stock could be instantaneously adjusted to the desired level at no additional cost, actual capital and desired capital would be

5. Bischoff, "Business Investment in the 1970s."

6. The primary reason for estimating separate equations will become apparent later in the paper. Although the explanatory variables for equipment are similar or identical for a given model, it turns out that the differential between predicted and actual investment is concentrated in the structures component.

7. J. Maurice Clark, "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles," *Journal of Political Economy,* vol. 25 (March 1917), pp. 217–35.

8. L. M. Koyck, *Distributed Lags and Investment Analysis* (Amsterdam: North-Holland, 1954); and Hollis B. Chenery, "Overcapacity and the Acceleration Principle," *Econometrica,* vol. 20 (January 1952), pp. 1–28.

equal; variations in output would imply proportional variations in the capital stock and corresponding violent swings in net investment. The fact is, however, that the nonresidential capital stock changes slowly over time, and net investment, while more volatile than output, is much less variable than such a strict accelerator model would imply. To explain the slow reaction of capital to output, "flexibility" is typically added to investment; for various reasons, the reaction of the capital stock to output is spread over a number of time periods, through a set of distributed lag coefficients (β_s):

$$I^N \equiv K - K_{-1} = \sum_{s=0}^{\infty} \beta_s(K^d - K^d_{-s}).$$

Thus

$$I^N = \alpha \sum_{s=0}^{\infty} \beta_s(\Delta Y_{-s}), \tag{2}$$

where I^N is net investment in time period t and K is the actual stock of capital. This flexible accelerator (equation 2) has remained a popular empirical representation of aggregate investment behavior, primarily because it fits observed series of investment and output well.

Although a number of theories have been proposed to explain the flexible accelerator model, perhaps the most satisfactory is an adjustment-cost approach first suggested by Eisner and Strotz.[9] In it, firms pay a penalty for having a capital stock different from the desired level and incur adjustment costs, A, in trying to move to that level:

$$A = f(K^d - K) + g(K - K_{-1}), \quad f(0) = g(0) = 0; \tag{3}$$

$$\text{otherwise,} \quad f > 0, \quad g > 0,$$

where

$f(\cdot)$ = cost of having a capital stock different from K^d, the static optimum for the output of the current period

$g(\cdot)$ = cost of adjusting the capital stock.

The actual net investment undertaken is the one that minimizes costs in the trade-off between f (having too much or too little capital) and g (incurring costs of adjustment). In principle, installation costs, rising supply prices for capital goods, and production lags could all be included in an adjustment-cost framework. If g displays the property that adjust-

9. Robert Eisner and Robert H. Strotz, "Determinants of Business Investment," in Daniel B. Suits and others, *Impacts of Monetary Policy,* a series of research studies for the Commission on Money and Credit (Prentice-Hall, 1963), pp. 59-338.

ment is increasingly costly (so that doubling investment more than doubles adjustment cost), then partial adjustment is optimal, and investment should move the capital stock only part way toward its desired level in any one period.[10]

The usual theoretical discussion of the flexible accelerator ends at this point, having either implicitly or explicitly assumed that expectations about future levels of output are static: expected future output is equal to its current level. Such an assumption is clearly unwarranted at a theoretical level; firms expect future output to move in a number of ways, and plan long-range production strategy ten or more years in advance. If expectations about future output are not static, then investment in time period t should be a function of all the expected future levels of output, which should in turn be functions of past output and any other past variables that are important in forming expectations of future output.[11]

Implicitly or explicitly, the modern interpretation of the accelerator model assumes that past levels of output are the most important determinants of expectations about future output, and that other variables that might have been included in the model either have little impact on expectations or are observed with such large errors that they are best omitted altogether in empirical work.

The discussion thus far has focused on net additions to the capital stock, and has ignored replacement investment. If it can be assumed that depreciation is approximately exponential and that the replacement of depreciated capital responds linearly to current and lagged output, then gross investment, I, can be represented as a distributed lag on output, plus a constant multiplied by the capital stock of the last period:[12]

$$I = \alpha \sum_{s=0}^{\infty} \beta_s \Delta Y_{-s} + dK_{-1}. \tag{4}$$

10. See Michael Rothschild, "On the Cost of Adjustment," *Quarterly Journal of Economics*, vol. 85 (November 1971), pp. 605–22.

11. For a discussion of some of the problems in specifying the lag structure in a simple model of this sort, see Marc Nerlove, "Lags in Economic Behavior," *Econometrica*, vol. 40 (March 1972), pp. 221–51. Such theoretical considerations have not yet proved fruitful in many empirical applications.

12. It has been correctly argued that replacement investment is not likely to follow automatically the depreciation of old capital. See, for example, Martin S. Feldstein and David K. Foot, "The Other Half of Gross Investment: Replacement and Modernization Expenditures," *Review of Economics and Statistics*, vol. 53 (February 1971), pp. 49–58. Nonetheless, equation 4 may still be a reasonable representation of gross investment if a higher capital stock implies higher replacement expenditure for some types of capital.

Equation 4, with a finite number of lag coefficients and adjustment for residual heteroscedasticity leads to equation 5, which is used below for estimation: for reasons explained in appendix A, I allow for the presence of a nonzero constant term,

$$(5) \qquad \frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N} b_s \frac{\Delta Y_{-s}}{YP_{-s}} + d\frac{K_{-1}}{YP} + u,$$

$$u = \rho u_{-1} + \epsilon, \qquad E(\epsilon_t \epsilon_s)\begin{cases} = 0 & \text{for } t \neq s \\ = \sigma_\epsilon^2 & \text{for } t = s, \end{cases}$$

where

I = investment in equipment or structures at 1972 prices
YP = potential GNP at 1972 prices; estimate of the Council of Economic Advisers
ΔY = $Y - Y_{-1}$, where Y is private nonresidential business output at 1972 prices, defined as the gross domestic product of the private business sector minus gross housing product
K = net stock of equipment or structures at 1972 prices
b_s = $\alpha\beta_s$.

Division of all variables (approximately) by potential GNP is based on the assumption that the standard deviation of the error variance rises in direct proportion with the size of the economy.[13]

ACCELERATOR-CASH FLOW MODEL

The theoretical justifications for adding a profits or cash-flow term to an accelerator investment equation can be grouped into two broad categories. First, changes in profits should convey some new information

13. The ΔY_{-s} term is divided by YP_{-s} instead of YP in order to use existing computer programs for estimating Almon distributed lags. By doing so, the variance of the estimated coefficients is increased very slightly.

Tests of heteroscedasticity using the Goldfeld-Quandt method indicate that the disturbance variance may increase slightly faster than the square of potential output for equipment, and slower than the square of potential output for structures. See Stephen M. Goldfeld and Richard E. Quandt, "Some Tests for Homoscedasticity," *Journal of the American Statistical Association,* vol. 60 (June 1965), pp. 539–47. Division by potential output in the estimation both of equipment and structures was chosen primarily for simplicity after it was determined that more complicated procedures give nearly identical results.

about the future profitability of a firm, possibly increasing expected future output and boosting the optimal future path of capital stock.[14] Second, internal funds could be less costly than external finance, if the market for borrowed funds is imperfect, perhaps because of differences in information about the riskiness of new investment.[15] Larger amounts of internal funds might therefore lower financing costs and increase investment demand. Eisner has investigated this "profits and output" approach to the estimation of investment demand using a number of different sets of data.[16]

The empirical specification of the accelerator-cash flow model is identical to the simple accelerator (equation 5), except that an additional distributed lag on the level of cash flow is included as an explanatory variable:

$$(6) \qquad \frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N} b_s \frac{\Delta Y_{-s}}{YP_{-s}} + \sum_{s=0}^{N} c_s \frac{CF_{-s}}{YP_{-s}} + d\frac{K_{-1}}{YP} + u,$$

where CF is the real cash flow of nonfinancial corporations. Nominal cash flow is the sum of after-tax profits, capital-consumption allowances without capital-consumption adjustment, and the inventory valuation adjustment. The investment deflator for equipment or structures (whichever is appropriate) is applied to nominal cash flow to derive CF.

NEOCLASSICAL MODEL

Both the simple accelerator and its cash-flow variant lack a feature that most economists consider crucial: investment does not depend on the price of capital in either model. Jorgenson and a number of colleagues have attempted to remedy this defect by developing a model based on the neoclassical principle that the optimal combination of

14. For discussions along this line, see Lawrence R. Klein, *Economic Fluctuations in the United States, 1921–1941* (Wiley, 1950); and Yehuda Grunfeld, "The Determinants of Corporate Investment," in Arnold C. Harberger, ed., *The Demand for Durable Goods* (University of Chicago Press, 1960), pp. 211–66.

15. Duesenberry has been a proponent of this view. See James S. Duesenberry, *Business Cycles and Economic Growth* (McGraw-Hill, 1958).

16. A good summary of this research is contained in Robert Eisner, *Factors in Business Investment* (Ballinger for the National Bureau of Economic Research, 1978).

factor inputs should be a function of their relative prices.[17] If output is produced under competitive conditions and technology can adequately be described by a Cobb-Douglas production function, the desired capital stock at each point in time should be a linear function of output:

$$K^d = \gamma \frac{pY}{C}, \tag{7}$$

where

γ = share of capital in output
p = price of output
C = rental price of capital services.[18]

Then if expectations are static so that future changes in output are unanticipated, net investment can be represented as a distributed lag on past changes in desired capital stock:

$$I^N = \sum_{s=0}^{N} \beta_s (\Delta K^d)_{-s}. \tag{8}$$

Adding the usual term dK_{-1} for the replacement of the capital lost to exponential depreciation, dividing by potential GNP to correct for heteroscedasticity, and adding a stochastic error term, Jorgenson's neoclassical investment model becomes:

$$\frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N} h_s \frac{\left(\Delta \frac{pY}{C}\right)_{-s}}{YP_{-s}} + d\frac{K_{-1}}{YP} + u, \tag{9}$$

where h_s equals $\gamma\beta_s$.

In essence, the neoclassical model is a variant of the accelerator equation, with the capital-output ratio allowed to vary inversely with the relative price of capital inputs. While the inclusion of relative prices is a step in the right direction by theoretical standards, empirically it could be

17. See, for example, Dale W. Jorgenson, "The Theory of Investment Behavior," in Robert Ferber, ed., *Determinants of Investment Behavior,* Universities-National Bureau Conference Series, 18 (National Bureau of Economic Research, 1967), pp. 129–55; or Robert E. Hall and Dale W. Jorgenson, "Application of the Theory of Optimum Capital Accumulation," in Gary Fromm, ed., *Tax Incentives and Capital Spending* (Brookings Institution, 1971), pp. 9–60.

18. The rental price of capital services is the cost of using one unit of capital goods for one year. Thus, in various forms, it includes terms for the interest rate, depreciation, various tax parameters, and inflation. The variant of the rental price of capital services used in estimating the neoclassical models is the one chosen by Hall and Jorgenson. See appendix B.

either better or worse. In general, investment should be a function of expected future interest rates, prices, and taxes. In addition, considerations of adjustment cost indicate that optimal net investment should follow a dynamic decision rule based on expectations about future output, as pointed out earlier in the discussion of the accelerator model. Equation 9 arises from strong simplifying assumptions about the way the relative price of capital services affects changes in the capital stock; these assumptions may or may not be empirically valid.

MODIFIED NEOCLASSICAL MODEL

One widely accepted variant of Jorgenson's neoclassical model has been analyzed in a number of articles by Charles Bischoff.[19] Bischoff's amendment to the neoclassical model arises from the empirical observation that most modifications in the capital-output ratio are embodied in *new* equipment and structures; existing capital goods are less often modified in response to fluctuations in the relative price of inputs. If factor proportions can only be altered ex ante, then the distributed lag of investment on changes in the relative price of capital services should have a different shape from the distributed lag of investment on changes in output. Bischoff's formulation of the investment function allows for such a difference in distributed lag structure:

$$(10)\quad I = a + \sum_{s=0}^{N} j_s \left(\frac{p_{-s-1}Y_{-s}}{C_{-s-1}}\right) + \sum_{s=0}^{N} k_s \left(\frac{p_{-s-1}Y_{-s-1}}{C_{-s-1}}\right) + dK_{-1} + u.$$

A major difference between equation 10 and the neoclassical equation 9 is that Y_{-s} is divided by C_{-s-1} instead of by C_{-s}, an alteration that makes investment a function of the *level* of the rental price of capital services, rather than a function of differences. The Cobb-Douglas form of the production function (with a unitary elasticity of substitution) is still assumed in Bischoff's formulation. When adjusted for heteroscedasticity, the modified neoclassical model in estimation form is

$$(11)\quad \frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N} j_s \left(\frac{p_{-s-1}Y_{-s}}{YP_{-s}\cdot C_{-s-1}}\right) + \sum_{s=0}^{N} k_s \left(\frac{p_{-s-1}Y_{-s-1}}{YP_{-s}\cdot C_{-s-1}}\right) + d\frac{K_{-1}}{YP} + u.$$

19. See Charles W. Bischoff, "The Effect of Alternative Lag Distributions," in Fromm, ed., *Tax Incentives and Capital Spending*, pp. 61–125, and "Business Investment in the 1970s."

SECURITIES-VALUE (Q) MODEL

The preceding four models are variations on a single theme; while some of the specifications include price and income variables, investment is primarily a function of changes in output. In contrast to these output-based models, the securities-value model attempts to explain investment on a financial basis in terms of portfolio balance. Roughly speaking, if the market value of a firm exceeds the replacement cost of its assets, it can increase its market value by investing in more fixed capital. Conversely, if the market value of a firm is less than the replacement cost of its assets, it can increase the value of shareholders' equity by reducing its stock of fixed assets.

Theoretical models emphasizing the relationship between investment and the ratio of market value to replacement cost, Q, have been proposed by a number of authors, particularly James Tobin.[20] Models of this type can be viewed as supplements to output-based models, rather than as direct competitors; both investment and the ratio of market value to replacement cost react to the same state of long-run expectations about future output and prices. When real capital is expected to be profitable in the future, both investment and Q rise. Conversely, pessimistic expectations about profitability in the near future should depress both variables. Investment and Q could be positively correlated, even if both are reacting to changes in output and prices.[21]

The empirical specification of the securities-value model is given in equation 12:

$$\frac{I}{K_{-1}} = a + \sum_{s=0}^{N} m_s Q_{-s} + u. \tag{12}$$

20. William C. Brainard and James Tobin, "Pitfalls in Financial Model Building," *American Economic Review*, vol. 58 (May 1968, *Papers and Proceedings, 1967*), pp. 99–122; and James Tobin, "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, vol. 1 (February 1969), pp. 15–29. A derivation of the same relationship that Tobin proposes in an adjustment-cost framework is given in Robert E. Lucas, Jr. and Edward C. Prescott, "Investment Under Uncertainty," *Econometrica*, vol. 39 (September 1971), pp. 659–81.

21. Ciccolo presents evidence that tends to reject this type of causality (output to Q, output to investment), although such statistical "causality" tests are open to question when any variable is chosen optimally. See John H. Ciccolo, Jr., "Money, Equity Values, and Income," *Journal of Money, Credit and Banking*, vol. 10 (February 1978), pp. 54–57.

Two problems occur in data used to construct Q that can impair the fit of equation 12 to the observed data.[22] First, the capital stock is not homogeneous, so that the estimate of replacement cost in the denominator of Q may have only a tenuous connection with the true cost of replacing existing capacity. In other words, the calculated Q is an average for all existing capital, rather than the marginal ratio that would be really appropriate for decisions about (marginal) additions to the capital stock. Second, the stock market exhibits a substantial amount of quarter-to-quarter noise that might rationally be ignored by investment decision-makers if short-term manipulation of a company's own stock is either costly or illegal.

Estimation Results: 1954:1 to 1973:2

Summary statistics resulting from the estimation of equations 5, 6, 9, 11, and 12 for equipment and structures are given in tables 1 and 2, respectively.[23] "Output-based" equations for equipment fit fairly well; their unadjusted standard errors of estimate average about one-quarter of a percent of potential GNP. The plot for the accelerator model in the top panel of figure 1 is typical. The securities-value equation (also shown in figure 1) does not fit as well, reflecting divergences between the behavior of investment and the stock market.

The results for structures are significantly worse, as illustrated in the bottom panel of figure 1 and in table 2, where estimated values tend to miss all but the largest movements, resulting in standard errors that are almost twice as large (in percentage terms) as those for equipment.

As of mid-1973, the two most promising models for explaining business fixed investment—the sum of equipment and structures—are the modified neoclassical model and the simple accelerator. While the modified neoclassical model looks substantially better in terms of historical fit (the unadjusted standard errors of estimate are about 30 percent smaller), it

22. For a detailed discussion of the construction of Q, see George M. von Furstenberg, "Corporate Investment: Does Market Valuation Matter in the Aggregate?" *BPEA, 2:1977,* pp. 347–97. The Q-ratio used in this study is von Furstenberg's, updated through 1978 by the author.

23. The first observation of the dependent variable in the estimation period is 1954:1. With five-year lags, differencing, and autocorrelation corrections, data are required on the independent variables from as early as 1948.

Table 1. Equations for Investment in Producers' Durable Equipment, Alternative Models, 1954:1–1973:2[a]

Independent variable and summary statistic	*Model*				
	Accelerator	*Accelerator-cash flow*	*Neo-classical*	*Modified neo-classical*	*Securities value*
Independent variable					
Constant	−11.5	−9.1	−9.6	−5.5	0.055
	(2.8)	(4.2)	(4.0)	(5.5)	(0.030)
Capital stock	0.19	0.13	0.20	0.13	...
	(0.01)	(0.06)	(0.02)	(0.08)	
Change in output[b]					
Current period	0.10	0.12	0.04	0.10	...
	(0.02)	(0.02)			
Lagged (quarters)					
4	0.18	0.19	0.09	0.14	...
	(0.02)	(0.05)			
8	0.14	0.14	0.08	0.09	...
	(0.02)	(0.06)			
12	0.08	0.05	0.03	0.11	...
	(0.02)	(0.04)			
16	0.04	0.01	0.01	0.09	...
	(0.02)	(0.03)			
20	0.02	0.02	0.01	0.06	...
	(0.02)	(0.02)			
Long-run effect	...	...	...	0.03	...
Lagged cash flow (quarters)					
4	...	−0.03	...	...	...
		(0.05)			
8	...	0.03	...	...	...
		(0.04)			
12	...	0.03	...	...	...
		(0.04)			
16	...	0.06	...	...	...
		(0.05)			
Sum of coefficients	...	0.20	...	...	...
		(0.19)			
Change in inverse of rental price of capital services[c]					
Current period	...	...	10.4	1.0	...
Lagged (quarters)					
4	...	...	26.5	2.4	...
8	...	...	21.6	3.5	...
12	...	...	9.8	4.7	...
16	...	...	2.6	5.6	...
20	...	...	3.5	6.5	...
Long-run effect	...	...	...	6.5	...

Table 1 (continued)

Independent variable and summary statistic	*Model*				
	Accelerator	*Accelerator-cash flow*	*Neo-classical*	*Modified neo-classical*	*Securities value*
Lagged Q (quarters)					
4	...	...	...	...	0.029 (0.011)
8	...	...	...	...	0.017 (0.014)
Sum of coefficients	...	...	...	...	0.168 (0.036)
Summary statistic					
Standard error of estimate[d]					
Adjusted	0.12	0.13	0.15	0.13	0.38
Unadjusted[e]	0.23	0.23	0.30	0.19	1.50
$\bar{R}^2$	0.97	0.97	0.96	0.97	0.94
Durbin-Watson	2.10	2.24	1.77	2.04	1.79
Rho	0.83	0.88	0.86	0.74	0.94

Sources: Investment, real output, cash flow, and the investment deflator are from U.S. Bureau of Economic Analysis, national income and product accounts. Capital stock data are from estimates by the Bureau of Economic Analysis of year-end totals, with quarterly data interpolated using quarterly data on real investment. The Q variable is from George M. von Furstenberg, "Corporate Investment: Does Market Valuation Matter in the Aggregate?" *BPEA, 2:1977*, pp. 351–54, updated by the author for 1977 and 1978 using the same methodology and flow-of-funds statistics supplied by the Board of Governors of the Federal Reserve System. Sources for the rental price of capital services appear in appendix B. The potential output series is from the Council of Economic Advisers.

a. Output is measured by real private nonresidential business output. Real cash flow is the nominal cash flow (the sum of after-tax profits, capital consumption allowances without adjustment, and the inventory valuation adjustment) of the nonfinancial corporate sector, deflated by the investment deflator for producers' durable equipment. The variable used as the rental price of capital services is described in appendix B. The Q variable is the ratio of market value to replacement cost. Capital stock is the end-of-quarter net stock of producers' durable equipment. All real variables are expressed in 1972 prices. The output-based equations have been corrected for heteroscedasticity using potential GNP, as described in the text. All lagged variables have been fitted using sixth-degree Almon polynomials with no end-point constraints. Only the coefficients on every fourth lag are presented here. The numbers in parentheses are standard errors.

b. Evaluated at the 1973 level of the rental price of capital services in the neoclassical and modified neoclassical models.

c. Evaluated at the 1973 level of output.

d. Expressed as a percent of potential GNP.

e. Calculated without autocorrelation correction.

should be noted that it has an additional distributed lag on the right-hand side, which contributes an automatic improvement in fit. This finding (that the accelerator model is a close competitor to the modified neoclassical model in explaining equipment investment) is different from results obtained by Kopcke and by Ando and others, who found that the modified neoclassical model fit historical data much better than a simple

Table 2. Equations for Investment in Nonresidential Structures, Alternative Models, 1954:1–1973:2[a]

Independent variable and summary statistic	*Model*				
	Accelerator	*Accelerator-cash flow*	*Neo-classical*	*Modified neo-classical*	*Securities value*
Independent variable					
Constant	4.6	5.0	0.8	6.2	0.519
	(2.8)	(3.0)	(3.8)	(2.3)	(0.015)
Capital stock	0.07	0.03	0.09	0.01	...
	(0.01)	(0.03)	(0.01)	(0.03)	
Change in output[b]					
Current period	0.02	0.02	0.02	0.01	...
	(0.01)	(0.01)			
Lagged (quarters)					
4	0.07	0.05	0.05	0.02	...
	(0.02)	(0.03)			
8	0.06	0.02	0.05	0.01	...
	(0.02)	(0.03)			
12	0.04	−0.01	0.04	0.05	...
	(0.02)	(0.03)			
16	0.02	−0.00	0.02	0.07	...
	(0.01)	(0.02)			
20	0.01	0.00	0.00	0.03	...
	(0.01)	(0.01)			
Long-run effect[c]	...	...	...	0.03	...
Lagged cash flow (quarters)					
4	...	−0.01	...	...	...
		(0.03)			
8	...	0.04	...	...	...
		(0.02)			
12	...	0.01	...	...	...
		(0.02)			
16	...	−0.02	...	...	...
		(0.03)			
Sum of coefficients	...	0.20	...	...	...
		(0.10)			
Change in inverse of rental price of capital services[b]					
Current period	...	...	5.2	0.9	...
Lagged (quarters)					
4	...	...	11.5	3.9	...
8	...	...	11.9	7.7	...
12	...	...	9.3	6.8	...
16	...	...	4.9	4.2	...
20	...	...	−0.2	7.1	...
Long-run effect[c]	...	...	...	7.1	...

Table 2 (continued)

Independent variable and summary statistic	*Model*				
	Accelerator	*Accelerator-cash flow*	*Neo-classical*	*Modified neo-classical*	*Securities value*
Lagged Q (quarters)					
4	...	...	...	...	0.011 (0.005)
8	...	...	...	...	0.002 (0.006)
Sum of coefficients	...	...	...	...	0.059 (0.015)
Summary statistic					
Standard error of estimate[d]					
Adjusted	0.09	0.09	0.09	0.08	0.14
Unadjusted[e]	0.19	0.18	0.26	0.13	0.81
$\bar{R}^2$	0.89	0.90	0.88	0.91	0.91
Durbin-Watson	1.91	1.98	1.87	2.09	2.09
Rho	0.90	0.89	0.93	0.78	0.98

Source: Same as table 1.

a. For a description of the variables used in the regressions, see table 1, note a. The investment, capital stock, and investment deflator variables are those for nonresidential structures. The output-based equations have been corrected for heteroscedasticity using potential GNP, as described in the text. All lagged variables have been fitted using sixth-degree Almon polynomials with no end-point constraints. Only the coefficients on every fourth lag are presented here. The numbers in parentheses are standard errors.

b. Evaluated at the 1973 level of the rental price of capital services in the neoclassical and modified neoclassical models.

c. Evaluated at the 1973 level of output.

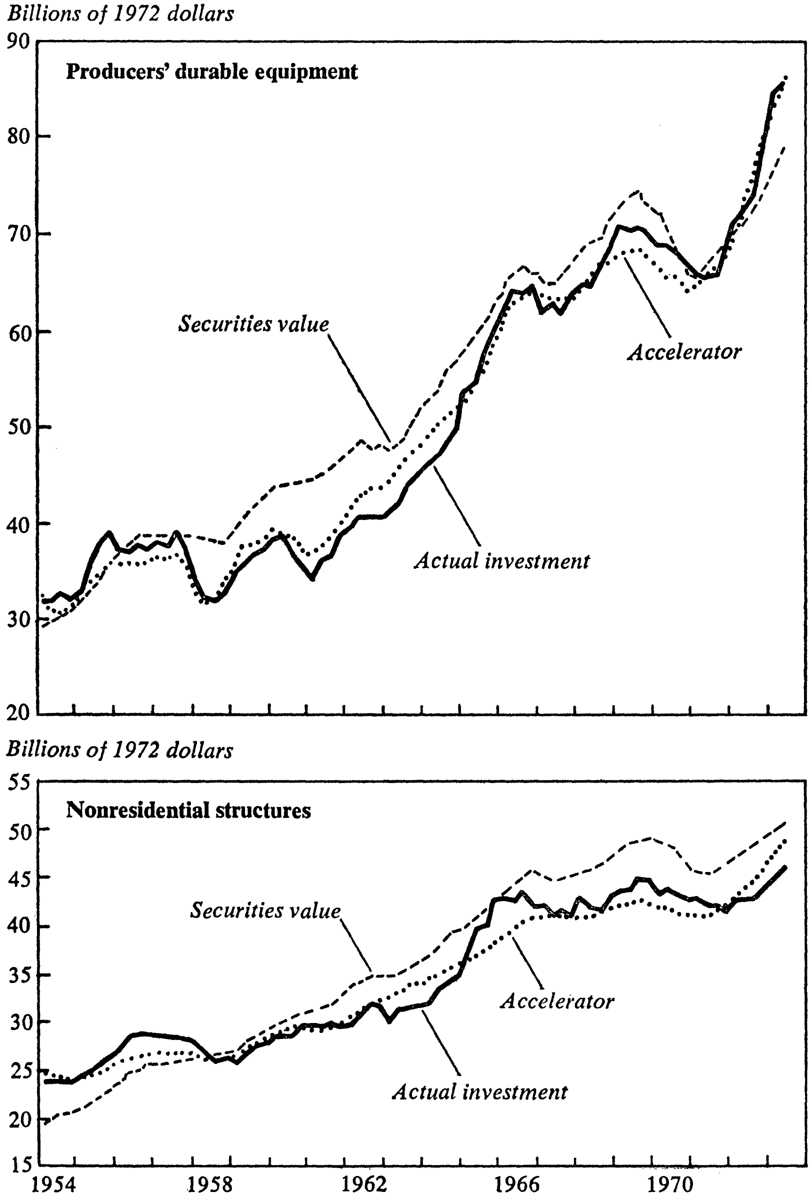
d. Expressed as a percent of potential GNP.

e. Calculated without autocorrelation correction.

accelerator.[24] Kopcke's results stem from his use of a distributed lag in the accelerator that is only one year long; experiments with unconstrained lags indicate that the accelerator effect may last up to five years. Ando and others estimate an accelerator model for equipment that has no constant and no dependence on the capital stock. Such constraints degrade its performance substantially. The standard errors for equipment reported in table 1 are about the same as those obtained by Kopcke and by Ando and

24. See Kopcke, "Behavior of Investment Spending"; and Albert K. Ando and others, "On the Role of Expectations of Price and Technological Change in an Investment Function," *International Economic Review*, vol. 15 (June 1974), pp. 384–414.

Figure 1. Investment in Producers' Durable Equipment and Nonresidential Structures, Estimates from the Securities-Value and Accelerator Models, and Actual Investment, 1954:1–1973:2[a]



Source: Actual—U.S. Bureau of Economic Analysis, national income and product accounts; estimates—equations in tables 1 and 2.

a. Note the differences in scale in the two panels.

Table 3. Estimated Standard Errors of Forecasts One Period and Many Periods Ahead, for Investment in Producers' Durable Equipment and Nonresidential Structures, Alternative Models

Percent of potential GNP

Model and type of investment	*Forecast error*[a] *One period ahead*	*Many periods ahead*
Producers' durable equipment		
Accelerator	0.170	0.229
Accelerator-cash flow	0.182	0.271
Neoclassical	0.206	0.299
Modified neoclassical	0.245	0.265
Securities value	0.221	0.588
Nonresidential structures		
Accelerator	0.123	0.200
Accelerator-cash flow	0.122	0.189
Neoclassical	0.127	0.245
Modified neoclassical	0.125	0.147
Securities value	0.125	0.495

Source: Same as table 1. Forecast errors were calculated from equations in tables 1 and 2. Actual data for the independent variables during the forecast period were used only for calculating the $\tilde{X}_s$, as defined in note a.

a. The forecast errors for one period and many periods ahead are calculated as

$$\hat{\sigma}_\epsilon \sqrt{1 + \tilde{X}_s'(\tilde{X}'\tilde{X})^{-1}\tilde{X}_s}$$

and

$$\hat{\sigma}_\epsilon \sqrt{\frac{1}{(1 - \hat{\rho}^2)} + \tilde{X}_s'(\tilde{X}'\tilde{X})^{-1}\tilde{X}_s}$$

respectively, where X_s is the vector of exogenous variables used in the forecast, X is the matrix of independent variables used in estimation, and the tilde (~) denotes the transformation $\tilde{X} = X - \hat{\rho}X_{-1}$.

others for the modified neoclassical model, but are substantially lower for the accelerator.[25]

Table 3 provides the estimated standard error of forecast for each of the ten equations; these statistics are a good measure of expected forecasting ability. For equipment, the accelerator model and the accelerator-cash flow model should generate the best one-period-ahead forecasts; for forecasts further in the future, the accelerator model is expected to be best. Even though the modified neoclassical model has a lower stan-

25. Kopcke's unadjusted standard errors are approximately \$4.9 billion (1972 prices) for the equipment accelerator and \$1.2 billion for a variant of the modified neoclassical model. Ando and others obtain \$4.2 billion (also in 1972 prices) for the accelerator and \$1.7 billion for the modified neoclassical model. In table 1 the same figures are approximately \$2.1 billion for the accelerator and \$1.6 billion for the modified neoclassical model.

dard error of estimate (see table 1), the high estimated variance for its coefficients degrades its estimated forecasting performance considerably. All the equations for structures have about the same forecast variance in the short run; for a longer period (like the interval from 1973:3 to 1978:4, which is the focus of the next section), the modified neoclassical model is expected to forecast best, with the accelerator-cash flow model doing a little better than the simple accelerator.

The high estimated standard errors for the neoclassical model indicate a fit that is significantly worse than that for the other three output-based models. This inferior statistical performance is discussed and analyzed in appendix A. The key point developed there is that the poor fit cannot be attributed merely to the assumed unitary value of the elasticity of substitution.

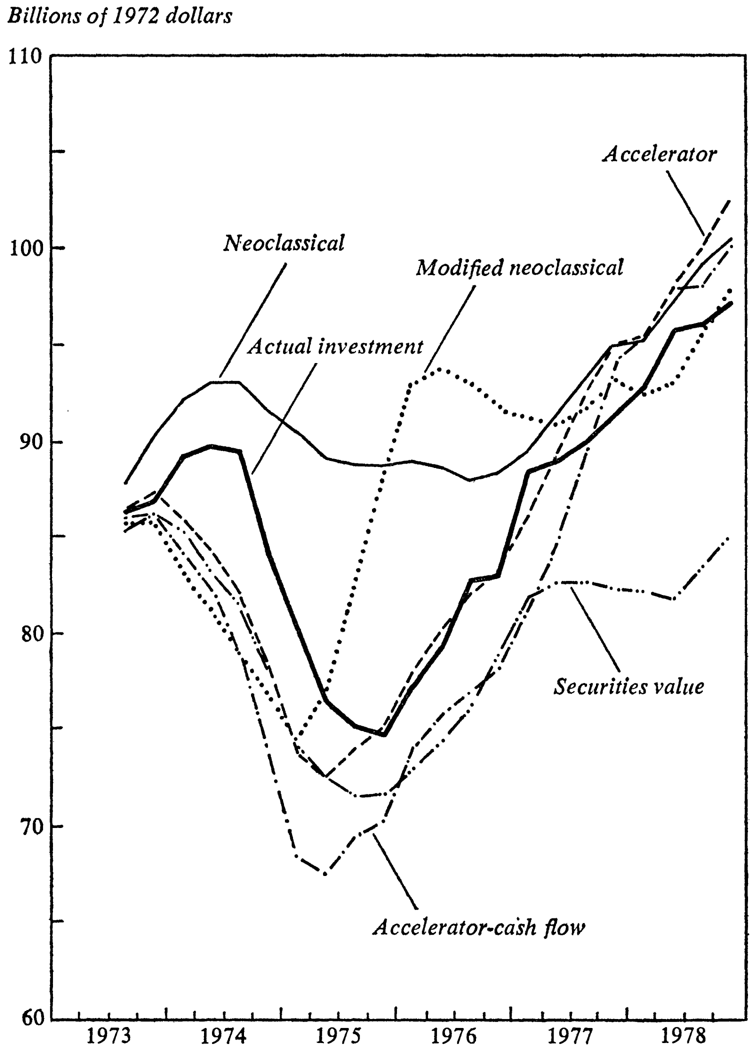
Forecast Results: 1973:3 to 1978:4

The predictive performance for the five models of investment behavior is compared in figure 2 for equipment, and in figure 3 for structures. The forecasts are generated using the models in tables 1 and 2 and the values for the independent variables that were actually observed for 1973:3 to 1978:4; thus they represent the projections that might have been made in mid-1973 if the future values of output and capital cost were known.[26] These are much better than anyone would have been able to make in 1973:2, not knowing the true values of the independent variables. Still, the forecasts are a stringent test of the models because until 1973:2, output grew rapidly, with little indication that a severe recession was close at hand.

Equipment investment was surprisingly strong for the years 1974–76. As output fell, it stayed virtually constant from 1974:1 through 1974:3. Four of the five models forecast equipment expenditures at or below the actual values until the cyclical trough in the first quarter of 1975. During the first two years of the recovery, the accelerator-cash flow, the securities-value, and (by a small margin) the accelerator models underpredict observed values; the neoclassical and modified neoclassical models fore-

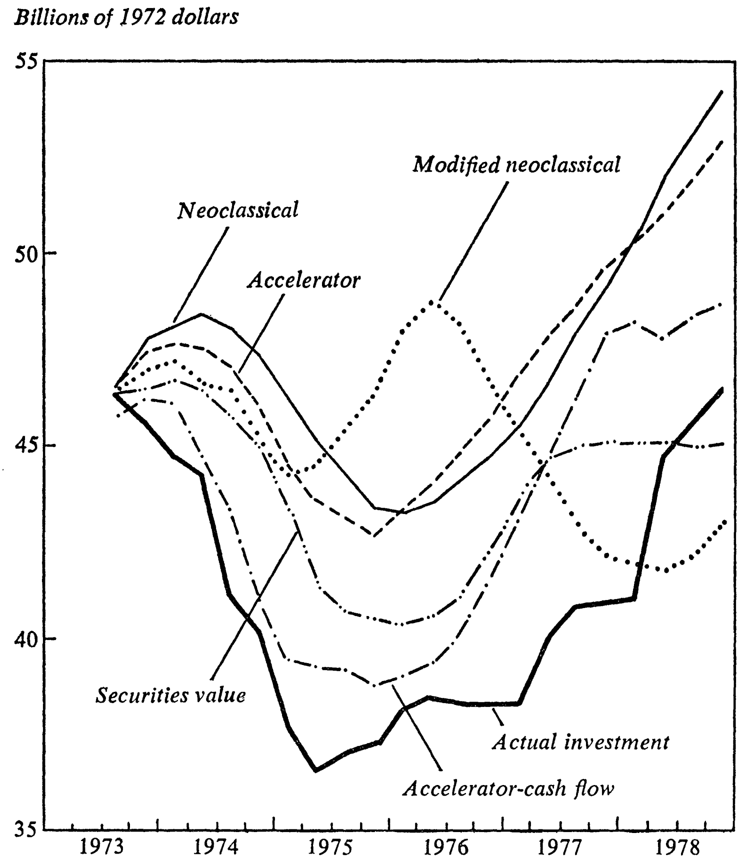
26. The variable for capital stock used in the forecast is $K = I + (1 - \delta)K_{-1}$, because using the actual capital stock includes some information about investment. This refinement changes the forecasts very little.

Figure 2. Projections of Investment in Producers' Durable Equipment, Alternative Models, and Actual Investment, 1973:3–1978:4



Source: Same as table 1. The forecasts were generated using the equations in table 1 and the actual data for the independent variables during the forecast period.

Figure 3. Projections of Investment in Nonresidential Structures, Alternative Models, and Actual Investment, 1973:3–1978:4



Source: Same as table 1. The forecasts were generated using the equations in table 2 and the actual data for the independent variables during the forecast period.

cast equipment investment higher than its actual value. In general, these results show a net tendency toward underprediction and thus are the reverse of those obtained by Kopcke, who found that forecasts of equipment investment were above actual values in 1975 and 1976.[27] Only during late 1977 and 1978 are the forecasts of the majority of the five models above the actual level of equipment investment and then by gen-

27. Kopcke, "Behavior of Investment Spending."

Table 4. Estimated and Actual Standard Errors of Forecast for Investment in Producers' Durable Equipment and Nonresidential Structures, Alternative Models, 1973:3–1978:4
Percent of potential GNP

	Producers' durable equipment		*Nonresidential structures*	
Model	*Estimated*	*Actual*	*Estimated*	*Actual*
Accelerator	0.23	0.25	0.20	0.54
Accelerator-cash flow	0.27	0.46	0.19	0.23
Neoclassical	0.30	0.56	0.25	0.46
Modified neoclassical	0.27	0.56	0.15	0.45
Securities value	0.59	0.32	0.50	1.05

Source: Same as table 1. The forecast errors were calculated using the equations in tables 1 and 2 and the actual data for the independent variables during the forecast period. The estimated standard errors of forecast are those presented in table 3 using the "many-periods-ahead" calculation. The actual errors are the ones consistent with the "many-periods-ahead" estimates; that is, they do not include the correction for autocorrelation.

erally narrow margins. All in all, equipment investment since 1973 has not been lower than what could have been expected.

The forecasts for structures tell a different story, as shown in figure 3. Four of the five models substantially overpredict investment for most of the 1973–78 period. Although the low explanatory power of the equations can be blamed for part of the difference between predicted and actual investment, the actual divergence is improbably large when judged by 1954–73 standards. For example, at the end of 1974, the difference between the observed structures investment and the accelerator prediction is over 15 percent, two-and-a-half times the standard forecast error. Structures investment fell much faster from mid-1973 to mid-1975 than the equations predict, and then responded sluggishly to increases in output in 1976 and 1977. Only in 1978 do the actual values start to gain ground on the forecasts, moving closer to predicted values. Aggregate structures investment from 1974 to 1978 was lower than would have been expected in 1973, given the paths of output, cash flow, and capital cost during those years.

The actual out-of-sample deviations for each equation are compared with their expected values in table 4. For equipment, the accelerator has the best forecasting performance, as expected from the within-sample statistics. The forecasts of the securities-value model and the accelerator-cash flow model also have standard deviations that are less than twice their estimated value.

The neoclassical and modified neoclassical models forecast significantly worse than expected, indicating that they may be subject to the same sort of specification error that has been found in other studies.[28]

For structures, all the models except the accelerator-cash flow exhibit significantly higher forecast errors than would have been expected from the fit between 1954 and 1973. Because no clear reason can be given for why cash flow should be such an important determinant of structures investment when it fails to add explanatory power to the accelerator model for equipment, the most plausible conclusion is that a shift in demand for nonresidential structures has occurred that is not captured by any of the five models.

A more stringent test for shifts in investment behavior may be constructed by comparing the sum of squared residuals for two regressions before and after mid-1973 with the sum of squared residuals for a single regression for the entire sample period. Such a test examines both forecast errors and functional dependencies that do not change the forecast. The F-statistics for such a test are given in table 5. For equipment, the accelerator, the accelerator-cash flow, and the modified neoclassical models show no shift; for the accelerator and accelerator-cash flow models, this confirms the forecasting results. The finding of no shift in coefficients for the modified neoclassical model is another indication of the high variance of its estimated coefficients.

The F-statistics for structures also confirm the results of the post-sample forecast; only the accelerator-cash flow model shows no shift. The other models indicate that the relationship between structures investment and its determinants has changed significantly since 1973.

A qualitative understanding of what has happened to nonresidential fixed investment can be obtained by directly comparing it to its determinants over the past seven years, as shown in figure 4. Equipment investment follows a cyclical pattern that lags output, as implied by a flexible accelerator. None of the capital-cost variables explains the strength of equipment purchases relative to output in 1974 and early 1975: at the end of 1974, the rental price of capital services for equipment using

28. Although coefficient estimates are not specifically given by Bischoff, experiments with his specifications indicate that his equations fail to forecast well outside their estimation interval. See his "Business Investment in the 1970s." The same problem is encountered in Kopcke, "Behavior of Investment Spending," and in Ando and others, "On the Role of Expectations of Price and Technological Change in an Investment Function."

Table 5. Standard Errors of Estimate for Equations Estimating Investment in Producers' Durable Equipment and Nonresidential Structures, Alternative Models, 1954:1–1973:2 and 1954:1–1978:4, and *F*-Tests of the Equality of the Estimated Coefficients, before and after 1973:2

Model and type of investment	*Standard error of estimate (percent of potential GNP)*		
	1954:1–1973:2	*1954:1–1978:4*	*F-statistic*[a]
Producers' durable equipment			
Accelerator	0.23	0.21	0.89
Accelerator-cash flow	0.23	0.21	0.49
Neoclassical	0.30	0.36	4.40[b]
Modified neoclassical	0.19	0.18	1.28
Securities value	1.50	1.77	8.26[b]
Nonresidential structures			
Accelerator	0.19	0.27	15.30[b]
Accelerator-cash flow	0.19	0.16	0.06
Neoclassical	0.26	0.29	3.48[b]
Modified neoclassical	0.13	0.26	18.41[b]
Securities value	0.81	0.84	4.22[b]

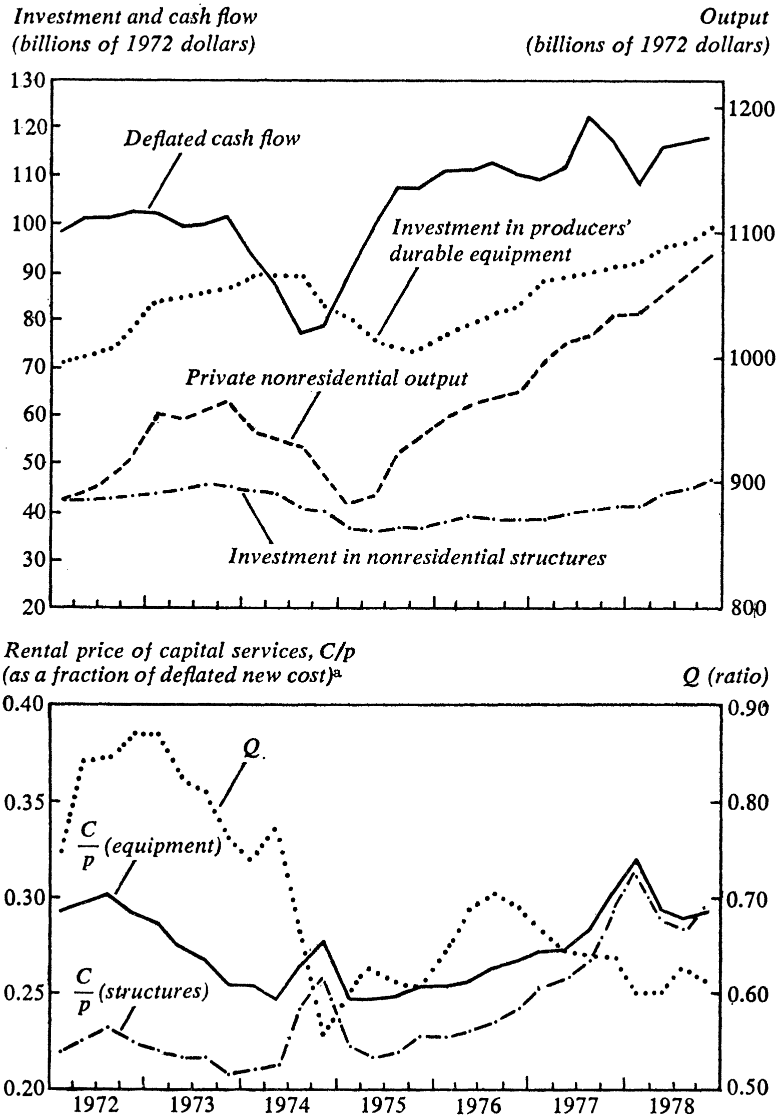
Source: Same as table 1, using the equation specifications of tables 1 and 2.
a. The calculated *F*-statistics do not include autocorrelation coefficients; that is, the estimated investment used in calculating the sums of squares does not include an autocorrelation correction. Since the autocorrelation coefficient is estimated, the *F*-tests are only asymptotic approximations.
b. The coefficient differences are significant at the 1 percent level.

both fixed and variable discount rates is close to its level of 1973:2. Deflated cash flow and Q both fell precipitously during the same period, so neither can explain the relatively high value of equipment investment.

The question for structures is just the opposite: why did it fall so fast in 1974 and 1975, given its weak relationship to output? A similar path is followed by Q, but the limited response of structures investment to Q between 1954 and 1973 forces the securities-value equation to overpredict between 1974 and 1978. The pronounced dip in deflated cash flow between the end of 1973 and the middle of 1975 coincides with the decline in structures investment, but does not explain the continuing weakness in 1976 and 1977.

Another problem with the structures forecast is that all the estimated equations display fairly large negative residuals in mid-1973; structures investment, even at its peak, was lower than historical relationships would indicate. These negative residuals cause most of the forecasts in figure 3 to rise in 1974, while actual investment falls. Evidently, the standard

Figure 4. Components of Nonresidential Fixed Investment and Its Determinants, 1972–78



Source: Same as table 1.

a. Only the rental price of capital services used in the equations for the modified neoclassical model is shown. The one used for the neoclassical model, with a constant before-tax rate of discount, showed little variation over the 1972–78 period. See appendix B for a description of these series.

Table 6. Investment in Nonresidential Structures, by Type, 1954–78
Percent of potential GNP

Year	*Commercial buildings*	*Industrial buildings*	*All other*
1954	0.65	0.59	2.50
1955	0.84	0.63	2.41
1956	0.95	0.80	2.42
1957	0.82	0.82	2.40
1958	0.82	0.54	2.30
1959	0.88	0.47	2.24
1960	0.91	0.61	2.21
1961	0.98	0.58	2.11
1962	1.03	0.57	2.13
1963	0.95	0.55	2.09
1964	0.97	0.64	2.14
1965	1.09	0.95	2.24
1966	1.01	1.13	2.28
1967	0.95	0.95	2.23
1968	1.03	0.79	2.24
1969	1.10	0.79	2.23
1970	1.02	0.67	2.18
1971	1.09	0.50	2.05
1972	1.15	0.39	2.04
1973	1.18	0.47	2.05
1974	1.01	0.49	1.87
1975	0.72	0.44	1.68
1976	0.70	0.39	1.77
1977	0.74	0.38	1.77
1978	0.82	0.48	1.82

Source: Bureau of Economic Analysis, national income and product accounts.

investment theories explain the structures aggregate poorly between 1954 and 1973, and do even worse between 1974 and 1978.

THE STRUCTURES PUZZLE: CLUES FROM DISAGGREGATED DATA

Disaggregated data on structures investment provide a partial explanation of the poor performance observed since 1973. The two most interesting components are commercial and industrial buildings, which are disaggregated from the total in table 6. During the 1954–73 period, investment in commercial structures (as a fraction of potential GNP) displays a pronounced upward trend. In 1974, the effect of lowered occupancy rates in a number of areas was compounded by falling output and serious liquidity problems for a number of real estate investment trusts, resulting in a reduction of almost $5 billion (1972 prices) in purchases of commercial structures from 1973:2 to 1975:4. The remainder of structures investment (with commercial structures excluded) is lower than its projected value by only about $2 billion in 1972 prices (or one standard error) for the years 1974–78.[29] Thus, apart from commercial structures, no significant deficiency remains to be explained.

It is reasonable to exclude the commercial component from the structures equations, although such "post-data model construction" can be faulted on purely statistical grounds. Expenditures on commercial structures seem to be immune to the standard accelerator effects; for example, they did not decline at all during the recession of 1958. Higher interest rates in 1966 and 1970 had some effect, but the upward trend of commercial structures until 1973 was fairly steady. The post-1973 "bust" in commercial structures can be viewed as a natural reaction to overbuilding and overextension of credit. By now, the glut of shopping centers and office space produced in the early 1970s has been eliminated, and if credit is available, investment in commercial structures should rise substantially in 1979 and 1980.

Industrial structures, in sharp contrast, had a weak performance during the late sixties and early seventies. That weakness contributed to the sizable negative residual of aggregate structures at the beginning of the post-sample period. As shown in table 6, as a percentage of potential GNP, expenditures on industrial structures (primarily factory buildings) fell from a Vietnam-inflated peak of about 1 percent in 1965–67 to an average of roughly one-half of 1 percent in 1970–73, and even less than that in 1974–78. While there was a resurgence in 1978, the poor performance of industrial structures may be indicative of problems caused by long-run pessimism, higher discount rates, or regulatory strangulation. Industrial structures are long-lived (tax lives of thirty years, useful lives even longer), so that increases in the discount rate should reduce investment in structures much more than investment in equipment, which has a shorter service life. "Horror" stories about the regulatory problems

29. This estimate was made using a projection from an annual accelerator model for structures investment (excluding commercial buildings).

encountered in building "green field" (new site) plants also find some support in the current low level of investment in industrial structures.

One additional explanation for the low level of structures investment is the possible overdeflation of current-dollar figures to obtain constant-dollar estimates. Nonresidential structures are heterogeneous, making it extremely difficult to measure their value in constant dollars. Because of these measurement problems, the deflator for nonresidential structures is based (in part) on increases in input prices, a procedure that may underestimate the extent to which inputs with rapidly rising relative prices (such as labor) can be contracted by greater use of other inputs whose prices are rising more slowly.

DISAGGREGATED EQUIPMENT INVESTMENT—ANOTHER PUZZLE?

While consideration of the structures investment data on a piece-by-piece basis seems to help explain the behavior of the structures aggregate during the 1973–78 period, exactly the opposite is true for equipment. While the equipment aggregate has followed its expected path over the past five years, its composition has been radically altered. Particularly in the last three years, the expansion in equipment investment has primarily occurred in motor vehicles: automobiles, buses, trucks, and truck trailers, as shown in table 7. Because the ratio of motor vehicles to other types of equipment varied within a fairly limited range around 25 percent between 1954 and 1971, the major rise in 1976–78 is especially surprising. Indeed, the sharp upturn in the most recent interval is much larger than any previous variation.[30]

It is tempting to conclude that the sharp upturn in purchases of motor vehicles is part of the same phenomenon that has weakened investment in other types of equipment and in structures: increasing risk premiums and discount rates have skewed investment toward assets with shorter lives. However, the rising proportion of motor vehicles in total purchases cannot be taken too seriously, given two problems with the data. First,

30. Simple accelerator models using annual data on vehicle and nonvehicle purchases indicate that the 1978 figure for motor vehicles is more than two standard deviations high, and that the nonvehicle component is more than two standard deviations low. Statistical analysis of the ratio of vehicles to nonvehicles is complicated by the fact that, under standard assumptions, it would have a noncentral Cauchy distribution.

Table 7. Investment in Producers' Durable Equipment, by Type, and Ratio of Motor Vehicles to All Other Equipment, 1954–78

	Type of equipment (billions of 1972 dollars)			
	Motor vehicles			
Year	Automobiles	Buses, trucks, and truck trailers	All other	Ratio of motor vehicles to all other equipment (percent)
1954	3.8	2.6	25.4	25.2
1955	4.9	3.4	27.6	30.0
1956	3.2	3.3	30.6	21.3
1957	3.7	2.9	31.3	21.1
1958	2.7	2.5	27.3	19.1
1959	3.8	3.0	29.3	23.2
1960	4.0	3.1	30.2	23.5
1961	3.7	3.2	29.4	23.5
1962	4.5	4.1	31.5	27.3
1963	4.3	4.3	34.1	25.2
1964	4.6	4.5	38.6	23.6
1965	5.7	5.6	44.7	25.3
1966	5.4	6.3	51.9	22.6
1967	5.2	5.7	51.5	21.2
1968	6.4	6.9	52.7	25.2
1969	6.7	8.2	55.4	26.9
1970	5.0	7.1	55.1	22.0
1971	6.9	7.9	51.5	28.7
1972	7.6	10.3	56.4	31.8
1973	8.7	12.5	64.3	32.9
1974	7.6	12.3	68.2	29.2
1975	7.3	9.0	60.2	27.1
1976	8.8	11.7	60.1	34.1
1977	10.6	15.5	63.7	41.0
1978	11.5	18.1	65.9	44.9

Source: Same as table 6.

the total for equipment investment is based on an average of estimates from two sources: data on commodity flows and data from the plant and equipment survey. The motor vehicles component is not estimated the same way, but is instead based on what the U.S. Department of Commerce considers to be more reliable data on sales and units. In the past three years, data on commodity flows have indicated higher investment than the plant and equipment survey; the compromise total in the national accounts is thus smaller than would have been estimated if the commodity-flow method had been used exclusively. Because the method for estimating motor vehicle purchases is closer to the commodity-flow approach, the divergence between the estimates from the plant and equipment survey and those from the commodity-flow method may be responsible for a substantial fraction of the apparent rise in motor vehicles relative to the total. Moreover, the method used to allocate private purchases of automobiles and trucks between investment and consumption could be subject to a wide margin of error. The steep rise in motor vehicles investment is a puzzle, but at this point it would be a mistake to attach any major significance to it.

1973–78 INVESTMENT PERFORMANCE: CONCLUSIONS

The results of estimating and comparing the forecasts of the various models can be summarized by answering the questions raised at the beginning of the paper. First, and probably most important, business fixed investment in the aggregate is only a little lower than might have been expected from its historical relationship to output and capital cost. In fact, the two minor surprises for equipment investment are that it did not fall further in 1974 and 1975, and that it has risen despite a stagnant stock market in the past two years. The structures component of business fixed investment has been between \$7 billion and \$10 billion (1972 prices) below projected levels since 1975, but most of this shortfall can be attributed to commercial overbuilding in the early 1970s and the collapse of the market for these structures in 1974. High rates of investment in motor vehicles combined with low investment in other types of equipment and in industrial structures give some credibility to the argument that risk premiums have risen over the past five years, biasing expenditures toward investment with shorter lifetimes. However, the strength of business fixed investment as a whole indicates that a major deviation from past relationships has not yet appeared.

Second, output is clearly the primary determinant of nonresidential fixed investment. Among the equipment equations, the simple accelerator has the lowest estimated forecast error; this statistic is confirmed by a superior performance in the post-sample forecasts. While the modified neoclassical model (with its extra variables) fits the historical data better, it does so at the expense of high variances of coefficients, which impair its forecasting performance.

The rental price of capital services, a conglomeration of interest rates and tax variables, is not very helpful in explaining quarterly data on business fixed investment in the United States over the past twenty-five years. This result should not be interpreted as a rejection of the role of prices in the determination of business investment; no reasonable economist would argue that a refundable tax credit of, say, 20 percent would not increase the demand for investment in the long run. Rather, it means that the effect of interest rates and tax changes must be estimated with more comprehensive data than the quarterly aggregates, and that these effects are likely to be felt only gradually, over long periods of time. For short-term forecasting (two years or less), the effect of moderate variations in taxes and interest rates is likely to be negligible; over longer periods it may be substantial, but cannot be estimated with any degree of accuracy from equations relating the quarterly aggregates.

The primary implication of these results for economic policy is that there is no quick and easy way to channel aggregate demand toward nonresidential fixed investment. The response of investment to direct incentives may be both slower and weaker than was indicated by Bischoff's model. In the short run, at least, the best way to keep investment spending up is to keep capacity utilization high.

The Investment Outlook through 1981

To investigate the possibilities for business fixed investment from 1979 to 1981, conditional forecasts were made with the accelerator model for equipment and with the accelerator-cash flow model for structures. The optimistic scenario is based on the Carter administration's forecast and projections for 1979–81. In it, real GNP grows slowly but does not decline over the next three years.[31] The pessimistic alternative is a model simulation by Data Resources, Inc., which forecasts faster growth in the first half of 1979, eventually followed by a year-long reces-

31. See *Economic Report of the President, January 1979,* pp. 97–106; and *The Budget of the United States Government, Fiscal Year 1980,* pp. 34–36. The administration is always careful to put ranges around its point estimates and stress that they are based on assumptions that may turn out to be false. The actual estimates used for the investment forecasts below are derived from the Data Resources, Inc. simulation CARTERCOUNTRY0126, which is in turn based on the economic assumptions in the 1980 *Budget.*

Table 8. Projected Output and Cash Flow under Optimistic and Pessimistic Assumptions, 1979:2–1981:4[a]

Billions of 1972 dollars

Year and quarter	Gross national product		Cash flow	
	Optimistic	*Pessimistic*	*Optimistic*	*Pessimistic*
1979:2	1,433.0	1,439.3	121.1	116.5
4	1,443.2	1,449.4	120.7	115.0
1980:2	1,464.7	1,404.6	123.9	111.7
4	1,489.0	1,387.9	130.7	113.3
1981:2	1,524.4	1,451.0	131.7	121.1
4	1,558.8	1,489.0	136.5	124.9

Sources: Derived from simulations of Data Resources, Inc. The optimistic forecasts are based on those in *Economic Report of the President, January 1979*, pp. 97–106; and *The Budget of the United States Government, Fiscal Year 1980*, pp. 34–36. The pessimistic forecasts assume a year-long recession in 1980. See *Data Resources Review*, vol. 8 (February 1979). The cash-flow variable is described in table 1, note a.

a. In 1978:4, real GNP and real cash flow were $1,414.7 billion and $118.5 billion, respectively.

Table 9. Projected Nonresidential Fixed Investment under Optimistic and Pessimistic Assumptions, 1979:2–1981:4[a]

Billions of 1972 dollars

Year and quarter	Producers' durable equipment		Nonresidential structures	
	Optimistic	*Pessimistic*	*Optimistic*	*Pessimistic*
1979:2	102.0	102.6	46.7	46.8
4	104.5	105.9	46.1	46.3
1980:2	108.0	103.1	45.1	43.7
4	108.8	95.6	45.3	41.2
1981:2	111.9	97.2	46.0	40.8
4	116.2	102.0	46.9	41.9

Sources: Same as table 8. The equations used to forecast investment are shown in the text.

a. In 1978:4, real investment in producers' durable equipment and in nonresidential structures were $98.2 billion and $46.7 billion, respectively.

sion in 1980.[32] The alternative assumed paths for output and cash flow and the resulting forecasts for equipment and structures investment are given in tables 8 and 9, respectively. The equations used to generate the investment forecasts were estimated using data from 1954 to 1978, where *IE* and *IS* are investment in producers' durable equipment and nonresidential structures, respectively, and *KE* and *KS* are the corresponding capital

32. The model simulation used was DEEPRECESSION0124. See the *Data Resources Review*, vol. 8 (February 1979).

stock variable.[33] (Here and elsewhere the numbers in parentheses are standard errors.)

$$\frac{IE}{YP} = \underset{(2.0)}{-11.6} + \sum_{s=0}^{20} b_s \frac{Y_{-s}}{YP_{-s}} + \underset{(0.013)}{0.187} \frac{KE_{-1}}{YP},$$

Durbin-Watson = 1.94; standard error = 0.00124; rho = 0.81;

selected lag coefficients: $b_0 = 0.084$, $b_4 = 0.172$, $b_8 = 0.144$, $b_{12} = 0.092$, $b_{16} = 0.049$, $b_{20} = 0.031$.

$$\frac{IS}{YP} = \underset{(2.0)}{6.5} + \sum_{s=0}^{20} b_s \frac{\Delta Y_{-s}}{YP_{-s}} + \sum_{s=1}^{16} c_s \frac{CF_{-s}}{YP_{-s}} + \underset{(0.0)}{0.017} \frac{KS_{-1}}{YP},$$

Durbin-Watson = 1.98; standard error = 0.00082; rho = 0.86;

selected lag coefficients: $b_0 = 0.026$, $b_4 = 0.060$, $b_8 = 0.036$, $b_{12} = -0.001$, $b_{16} = -0.005$, $b_{20} = -0.004$; $c_4 = -0.004$, $c_8 = 0.021$, $c_{12} = 0.024$, $c_{16} = -0.014$; $\sum_{s=1}^{16} c_s = 0.228$.

Under the administration's assumption of slow but steady growth and declining inflation, nonresidential fixed investment rises at an average rate of about 4.3 percent per year, roughly consistent with the administration's projections.[34] Most of the increase is in equipment, with structures remaining at about their current level. If the earlier discussion analyzing the special nature of commercial structures has any validity, the projection for total structures may be low; it is easy to envision commercial structures continuing their rise in response to lower vacancy rates.

Under the "DEEPRECESSION" scenario of Data Resources, Inc., however, the outlook for nonresidential fixed investment is much worse. The equipment plus structures total is almost 5 percent less in 1980:4 than the level attained in 1978:4. Instead of continuing to rise, the ratio of business fixed investment to potential GNP falls to 9.0 percent, sub-

33. These two equations were used because they had the best performance in the post-sample forecasts discussed above. Forecasts with the other models generate results consistent with their 1973–78 forecasting behavior. For example, the modified neoclassical model predicts a wider swing in equipment investment in the recession scenario, while the neoclassical model shows little response to variations in output. The securities-value model has almost no forecasting capability because it requires a stock market forecast.

34. See the 1979 *Economic Report,* pp. 97–99. The investment forecasts are not determined simultaneously with output; the investment forecasts in tables 8 and 9 could be either higher or lower than the investment component of aggregate demand used in generating forecast values for output, interest rates, or prices.

stantially below the level required to sustain even moderate growth of the ratio of capital to labor.

All the evidence indicates that output will be the primary determinant of business fixed investment over the next three years. If a recession can be avoided and capacity utilization remains high, as in the Carter administration's optimistic scenario, then business fixed investment will continue to rise, approximately maintaining its fraction of total output. Conversely, if rising prices and high interest rates put the economy into a tailspin, the percentage of nonresidential fixed investment in total output will fall, with adverse consequences for future productivity and inflation.

APPENDIX A

Issues in the Estimation of Investment Models

THE FOLLOWING NOTES elaborate on several analytical issues relevant to the estimation of investment models.

The Direction of Causation

Nonresidential fixed investment is only one of the components of output that can reasonably be called "investment"; residential structures, consumer durables, and some components of government output are also deferrals of present consumption for future output. Thus, while in the aggregate "investment" can rise only if "saving" is also increased, the total for ex post saving can be allocated in a number of ways, depending on the relative demand for each component. The effect of increased investment demand on output, interest rates, and prices is clearly a problem for any equation for aggregate investment demand, but perhaps not a major problem when only a part of total investment is being estimated. In addition, regressions of investment on future and past changes in output indicate that output is exogenous in the Granger-Sims sense.[35] In a

35. C. W. J. Granger, "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica,* vol. 37 (July 1969), pp. 424–38; and Christopher A. Sims, "Money, Income and Causality," *American Economic Review,* vol. 62 (September 1972), pp. 540–52.

test for the effect on investment of output changes over eight future quarters, the values of the F-statistic are 1.49 for equipment and 0.35 for structures, both far below the 2.77 value that would be significant at the 5 percent level.

Level versus Change in Output

The accelerator model (equation 5) is estimated by specifying investment as a distributed lag on past *changes* in output as indicated by the theory. This formulation contrasts with recent estimates of the accelerator, which specify investment as a function of the *level* of output,[36] as given in equation A-1:

$$\text{(A-1)} \qquad \frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N+1} n_s \frac{Y_{-s}}{YP_{-s}} + d\frac{K_{-1}}{YP} + u.$$

Equations 5 and A-1 differ by only one linear restriction; if 5 is the true relationship, then

$$n_0 = b_0, n_1 = b_1 - b_0, \ldots, n_N = b_N - b_{N-1}, \quad n_{N+1} = -b_N.$$

A test of this linear restriction indicates that it is met almost exactly. While the differences formulation (equation 5) is robust with respect to the specification of the polynomial distributed lag, the levels formulation (equation A-1) is more sensitive. This is because the polynomial restriction requires some degree of smoothness in the b_s coefficients: if b_0 and b_1 have similar values that are not close to zero, specifying a low-degree polynomial for the n_s coefficients can seriously distort the accelerator.

The Constant Term in the Accelerator Equation

According to a simple interpretation of equation 5, the constant term should be zero, and the coefficient of the capital stock should equal the annual depreciation rate. There are two reasons why this is not the case. First, the depreciation behavior of the net capital stock figures is only approximately exponential. If depreciation is exponential, then:

$$\text{(A-2)} \qquad K = (1 - \delta)K_{-1} + I, \qquad \text{or} \qquad K - I = (1 - \delta)K_{-1}.$$

36. For example, see Bischoff, "Business Investment in the 1970s," and Kopcke, "Behavior of Investment Spending."

Thus in a regression of the capital stock minus investment on the capital stock lagged one year, the constant term should also be zero. Instead, the constant terms are found to differ significantly from zero when the following equation is fitted over the 1948–78 period:

$$\frac{K - I}{YP} = \frac{a}{YP} + b\,\frac{K_{-1}}{YP} + u.$$

The key coefficients are

	Coefficient	
	a	*b*
Producers' durable equipment	6.00	0.827
	(0.45)	(0.002)
Nonresidential structures	−1.81	0.947
	(0.25)	(0.001)

It is to be expected that the coefficients on the constant terms here are of opposite signs from those obtained in the estimates of equation 5, as shown in tables 1 and 2.

For equipment, the depreciation rate is higher in later years than in earlier years; note that with a constant term, the estimated depreciation rate is $\hat{\delta} = -\,a/K_{-1} + (1 - b)$, which rises as K_{-1} rises. For structures, the reverse is true.[37]

Deviation from exponential depreciation explains only part of the constant term in either the structures or equipment accelerator equations. The other part of each constant is related to the output term. A negative constant term in the estimate of equation 5 for equipment allows the accelerator effect to be stronger, generating larger investment changes for a change in output. As long as the equation is given a dynamic interpretation, such an increase in the output response offset by a negative constant term is perfectly reasonable.[38] The reverse is true in the corresponding structures equation: the constant term is positive. The accelerator effect is smaller, generating less investment response to changes in output. A visual

37. The U.S. Bureau of Economic Analysis calculates net capital stocks by using straight-line depreciation over an assumed asset life for each type of asset. There is an additional complication caused by asset transfers between the business and household sectors. Thus exponential depreciation is only a convenient approximation.

38. If an accelerator is viewed as an adjustment to some static equilibrium, then if changes in output are zero, net investment should be zero also. A negative constant in this context implies that constant output would result in negative net investment, an inconsistent result.

inspection of the data for output, structures investment, and equipment investment would have yielded similar results; structures investment responds only weakly to changes in output, while equipment investment swings more widely over the business cycle.

The Fit of the Neoclassical Equation

The performance of the neoclassical equations is disappointing. A possible reason for that poor performance may be that the calculated series for the rental price of capital services varies much more than its expected future value. Changes in the interest rate, dividend-price ratio, or even the corporate tax rate probably change expectations slowly. The problem may be characterized, then, as a case of errors in variables, with the calculated rental price of capital services varying in some erratic way around the expected value used by investment decisionmakers. This variation probably biases the h_s coefficients toward zero, raising the coefficient on capital stock (essentially a trend term), and increasing the standard error of estimate.

The effect of the rental price of capital services can be seen most clearly by considering a more general model that includes the neoclassical model and the accelerator model as special cases:

$$\text{(A-3)} \quad \frac{I}{YP} = \frac{a}{YP} + \sum_{s=0}^{N} q_s \frac{\left[\left(\frac{p_{-s}}{C_{-s}}\right)^{\eta} Y_{-s} - \left(\frac{p_{-s-1}}{C_{-s-1}}\right)^{\eta} Y_{-s-1}\right]}{YP_{-s}} + d\,\frac{K_{-1}}{YP} + u,$$

where η is the elasticity of substitution between capital and labor in production. Equation A-3 reduces to the accelerator model (equation 5) when η is zero, and to the neoclassical model (equation 9) when η is one. The equation can be derived from an analysis similar to that of Jorgenson when the production function exhibits a constant elasticity of substitution.[39]

The standard error of estimate for equation A-3 as a function of η is shown in table A-1.

39. Jorgenson, "Theory of Investment Behavior."

Table A-1. Standard Error of Estimate from Equation A-3 as a Function of the Elasticity of Substitution, for Investment in Producers' Durable Equipment and Nonresidential Structures, 1954:1–1973:2

Percent of potential GNP

Elasticity of substitution, η	Producers' durable equipment		Nonresidential structures	
	Adjusted[a]	*Unadjusted*[b]	*Adjusted*[a]	*Unadjusted*[b]
−0.50	0.154	0.383[c]	0.089	0.235[c]
−0.25	0.124	0.232	0.088	0.213[c]
0.00	0.123	0.227	0.087	0.191
0.25	0.130[d]	0.273[c]	0.087	0.196[d]
0.50	0.138[c]	0.291[c]	0.087	0.186
0.75	0.145[c]	0.298[c]	0.088	0.243[c]
1.00	0.150[c]	0.301[c]	0.089	0.258[c]
1.25	0.153[c]	0.302[c]	0.090[d]	0.264[c]
1.50	0.155[c]	0.303[c]	0.091[d]	0.265[c]

Source: Same as table 1.
a. Estimated standard error of ϵ, where $\epsilon = u - \rho u_{-1}$.
b. Estimated standard error of u.
c. Increase in standard error (asymptotically) significant at 1 percent level.
d. Increase in standard error (asymptotically) significant at 5 percent level.

For equipment, the accelerator model (η equal to zero) performs best; even small positive values for the elasticity of substitution are rejected by the data. The −0.25 value for η can be ruled out on theoretical grounds because a negative value for η implies that the investment tax credit or accelerated depreciation actually *decreases* the capital stock in the long run. The results for structures are not as sharp; a value of 0.5 for the elasticity of substitution does insignificantly better than the simple accelerator. It is interesting to note that the autocorrelation-adjusted standard error contains almost no information about the value of η. Evidently equation A-3 fits poorly enough in the range ($0 \leq \eta \leq 0.5$) that the poorer fit for other values of η can be offset by a slightly higher autocorrelation coefficient.

A test analogous to the one performed in table A-1 cannot be constructed for the modified neoclassical model because when the elasticity of substitution approaches zero, the regressor matrix becomes singular. However, experimentation with a generalized version of equation 11 indicates that lower values of the elasticity of substitution may be appropriate, and that the "errors in variables" argument made for the neoclassical model may also apply (weakly) to the modified neoclassical model.

APPENDIX B

Construction of the Rental Price of Capital Services

THE FOLLOWING is a description of the variables used in the estimation of the series on the rental price of capital services, C. For equipment, it is

$$C = \frac{p_E \cdot (\delta_E + r) \cdot (1 - RITC - D \cdot ZE \cdot U \cdot RITC - ZE \cdot U)}{(1 - U)},$$

and for structures,

$$C = \frac{p_S \cdot (\delta_S + r)(1 - ZS \cdot U)}{(1 - U)},$$

where

δ_E = depreciation rate for net nonresidential stock of producers' durable equipment; estimated by regression, δ_E = 14.91 percent a year

δ_S = depreciation rate for net stock of nonresidential structures; estimated by regression, δ_S = 5.82 percent a year

D = dummy variable, equal to 1.0 when the Long amendment to the Revenue Act of 1962 on depreciation of the investment tax credit was in effect in 1962 and 1963, and zero thereafter

p_E = deflator for nonresidential investment in producers' durable equipment (1972 = 1.00)

p_S = deflator for investment in nonresidential structures (1972 = 1.00)

r = discount rate[40]

40. For the neoclassical model, $r = 0.2(1 - U)$, the series used in Hall and Jorgenson, "Application of the Theory of Optimal Capital Accumulation." For the modified neoclassical model, $r = (1.5\ r_{stock} + 1.5\ r_{bond})(1 - 0.2U)$, an average of the results obtained by Ando and others, "On the Role of Expectations of Prices and Technological Change in an Investment Function." The r_{stock} term is the ratio of dividend to price for the Standard and Poor's 500 index; the r_{bond} term is the Baa corporate bond rate minus the expected rate of inflation. Following Ando and others, the expected rate of inflation is a constant 1 percent a year through 1964, and for subsequent years equals

$$\left(\sum_{i=0}^{11} 0.87^i \left(\frac{\Delta p}{p}\right)_{-i} \Big/ \sum_{i=0}^{11} 0.87^i \right),$$

where $\left(\frac{\Delta p}{p}\right)_{-i}$ is the annual rate of change of the deflator for private output lagged i quarters.

RITC = rate of investment tax credit on equipment investment
U = corporate tax rate, defined as the highest marginal rate on corporate income
ZE = present value of a dollar's worth of depreciation on equipment, a combination of sum-of-the-digits and straight-line depreciation
ZS = present value of a dollar's worth of depreciation on structures.

The deflators, p_E and p_S, are from the Bureau of Economic Analysis, national income and product accounts; *RITC* is the Data Resources, Inc., series for the investment tax credit, except for a modification in 1969; *U*, *ZE*, and *ZS* are derived from data supplied by the U.S. Department of the Treasury.

Comments and Discussion

Alan Greenspan: Clark has presented an interesting analysis of various approaches to investment. I found the results quite useful, and consider some of the results of the models for equipment especially illuminating. I must say that, as I read the paper, however, answers were not forthcoming to a number of questions that I had expected to be addressed. Also, I was struck by the implicit assumption in the paper that investment in equipment and investment in structures are determined independently, even though their determinants are modeled similarly.

In fact, we know that that is not the way appropriations are implemented at the corporate level. The appropriations committees or plant and equipment committees within businesses rarely, if ever, focus on the question of structures versus equipment per se. Essentially those committees consider projects that invariably have certain mixes of plant and equipment. In many instances, there are actually problems of defining where to split one from the other. Obviously a strong interdependence between plant and equipment exists, especially in a period of significant capacity expansion, partly because building a plant requires equipment to go into it.

It is my impression that, if Clark fitted relationships to the sum of equipment and structures, the results of his "horse race" among models would come out somewhat differently. In particular, I suspect that the performance of the Q relationships would probably improve; while Q performs terribly in equations for both equipment and plant, the residuals suggest that combining them would give a significantly better fit.

I believe that the way the system really functions is that aggregate plant and equipment or, more precisely, aggregate appropriations, are determined at any particular time by the variables specified in the models, while other forces determine the internal structure of capital formation—the composition of plant and equipment and of various subcategories of investment.

I suspect that the division between equipment and structures is merely part of the break between long-lived and short-lived assets. The key issue is not whether the investment is, in fact, plant or equipment, but whether it is a short-lived asset with a rapid return or a long-lived asset in which much of the potential or expected cash flow comes from the later years of the project.

If the latter is the case, the recent behavior of both structures and motor vehicles can be explained in terms of shifting hurdle rates of return. Although the data are not easy to obtain, the pattern of investment clearly suggests a significant increase in the hurdle rate of return in the 1970s, especially in the mid-decade. It is clear that the higher the hurdle rate of return, other things being equal, the greater the present value of short-lived assets relative to long-lived assets. Thus a rise in hurdle rates should skew the distribution of the lives of capital goods toward shorter-lived assets. One consequence would be a smaller proportion of structures and a larger proportion of motor vehicles—a prediction supported by the data. Further confirmation can be found in the distribution of research and development expenditures, which have many of the characteristics of capital investment. Excluding government-financed research and development, the proportion of long-lived research, relative to short-payoff development expenditures, should fall in a period of rising hurdle rates of return. And that can explain the virtual drying up of privately financed basic research, especially in industry. While there are a number of other explanations, such as the effect of government regulation, I am reasonably confident that a careful look at individual budgetary procedures would reveal that high hurdle rates, stemming from high risk premiums, are the major explanation.

What I know about investment decisionmaking causes me to doubt statistical procedures that make plant or equipment expenditures the dependent variable and then estimate distributed lags on a number of explanatory variables. Can such equations track the process that actually occurs? Capital expenditure committees of corporations act on *appropriations* in the light of variables such as cash flow, *Q*, or some accelerator measure. The lag between those factors and appropriations is short. And then expenditures flow from appropriations with varying lags. While

Almon lags are helpful in fitting such relationships, they clearly do not follow a fixed lag distribution as the Almon lag implies. By making investment *expenditures* the dependent variable and linking them by a fixed lag distribution to the factors that actually determine capital appropriations, the models waste information and turn into reduced forms rather than structural explanations. I would urge researchers on capital spending to take a more careful and detailed look at the appropriations-expenditure process.

Next, I want to mention some data problems. There is an interesting table in the *Survey of Current Business* (March 1979, p. 6) that raises major questions about the quality of the relevant data. The published figures on nonresidential fixed investment are essentially an average of two methods of estimation—one based on the plant and equipment survey and the other on "commodity flow." For 1977 and 1978, the published figures show increases in nominal expenditures of 15.7 percent and 16.9 percent, respectively. Yet the estimate based on the plant and equipment survey rose only 12.5 percent in 1977 and 11.8 percent in 1978, while the commodity-flow procedure indicates much larger increases of 18.1 and 18.8 percent, respectively, for the two years. Although earlier years do not show that much divergence, these are significant differences. A model to forecast numbers is fine, but it is disturbing to remain so uncertain about the meaning of the numbers we are forecasting.

On a minor issue, I have reservations about any classification that groups the structures of nonprofit institutions and churches with those of manufacturing firms and public utilities. I would not expect these subcategories to be related to Q in the same way and to the same extent.

A problem also arises with leased equipment. Apart from taxes, theoretically it should make no difference whether the ultimate user purchases the asset or rents it from someone else who does the purchasing. But I suspect that, with the significant shift in recent years toward equipment leasing—mainly from commercial bank holding companies—the determinants of capital investment in that area may be changing. I also wonder whether leased equipment may account for some of the difference between the estimates based on the plant and equipment survey and those from the commodity-flow approach.

Two other analytical issues remain. First, no believer in structural models can be comfortable with Clark's explanation of the sharp decline in commercial structures in 1974. I do not disagree with the explanation, but I want to stress that it is not grounded in any model. Such an abrupt and major change should be tracked by any model worth its salt. If a model cannot do that, one must seriously question whether it has any value.

Second, I am troubled by the distinction between short-run and long-run investment models. It seems reasonable to conclude from the paper that output-determined models are appropriate and provide the best fit for five years, but that they cannot be conceptually applicable to the longer term. But then we need some way to move (perhaps by a phase-in procedure) from a short-term model to a long-term one. I am uncomfortable with the implication that a valuable short-term forecasting device exists, which, carried out to the longer term, arrives at a contradiction. It raises serious questions about whether one is capturing the forces that drive the system. That discomfort is relieved if one can believe the securities-value, or Q, model because that theory is consistent in the short term and long term. With plant and equipment combined, perhaps it would show up better in the horse race.

Stephen M. Goldfeld: Peter Clark is to be commended for providing us with a comprehensive and carefully executed econometric study of investment behavior. In keeping with the Easter-Passover season, the paper begins with "the four questions" which, in this spirit, might be paraphrased "why is the investment equation different from all other macroeconometric equations that seem unstable in recent years?" To answer this question, Clark estimates five competing models of investment for a sample period ending in mid-1973. These estimates, which are reported separately for equipment and structures, are then extrapolated through 1978, providing a basis both for a further comparison of the alternative models and for evaluating whether recent investment spending is weaker than might have been expected, given its determinants.

On this latter score, Clark concludes that equipment investment is roughly on track but that investment in structures is somewhat lower than what might be expected. Clark clearly prefers the accelerator to any model utilizing a cost of capital variable, and indicates that the rental price of capital has no role to play in explaining quarterly data on investment. I will concentrate my remarks on examining these two issues, focusing first on the cost of capital.

Both the modified neoclassical model (which uses a rental price variable) and the accelerator model do a reasonable job of explaining investment in equipment through mid-1973. However, because these models are nonnested—that is, neither is a special case of the other—it is slightly problematic to choose between them. Standard errors within the sample favor the modified neoclassical model, but a forecasting criterion (measured either by anticipated forecast errors or actual forecasts) reverses the ranking, leading Clark to prefer the accelerator model. While forecasting ability is a reasonable criterion for model choice, the particular evidence Clark presents may be a bit limited. First, it focuses on only a single forecasting episode; and second, it assesses forecasting accuracy in the context of an individual equation and not a complete model. Apart from these points, however, there are a number of other reasons for caution before dismissing a rental price variable. In explaining the apparent failure of this variable, Clark suggests that a good part of the problem may stem from his inability to measure properly the cost of capital due, for example, to such things as measurement error, aggregation bias, or inadequate information on expectations. Because these difficulties plague most macroeconometric efforts, the distinguishing feature of the present case is that the variable of concern does not seem to "work" and, if we believe it should, we have to ask what might be done about it. A number of possibilities can be raised.

The first concerns alternative measures of the rental price variable. It is not difficult to develop a number of proxies for the cost of capital—based, for example, on alternative measures of expected inflation—which are needed to estimate a real rate of return. Clark tried with little success but hardly exhausted the possibilities. In this regard there may be some mileage in rethinking the way inflation affects the depreciation adjustment. In general, it is not clear to me that the conventional cost-of-capital variable is well-suited to cope with the kinds of institutional changes that can emerge in a world of rapid inflation. Another possibility, touched on by Alan Greenspan, is that the cost-of-capital variable may need to be modified by inclusion of a risk premium. Certainly numerous stories point in this direction.

There are also a number of econometric issues concerning this variable. If, for example, measurement error is taken seriously, it might be more appropriate to rely on instrumental variable techniques. Another issue concerns the functional form in which the cost-of-capital variable is introduced. Clark explores this in the context of the neoclassical model, but more could probably be done. A third econometric issue is the high degree of serial correlation, which in fact is evident in all the model specifications. This somewhat complicates model comparisons and forecasting exercises because different answers may be found depending on whether an equation is given "credit" for the serial correlation coefficient. Perhaps, more importantly, the high degree of serial correlation also raises suspicions that there may be some omitted variables in the specifications.

On balance, then, a number of caveats apply to Clark's pessimistic conclusion concerning the role of a cost-of-capital variable. However, even after a number of alternatives are tried, it may be the case that one cannot pin down the effect of a rental price variable with aggregate quarterly time-series data. The preferred strategy may be the imposition of some prior constraints on the impact of the rental price variable. Such constraints have been utilized with some success in conjunction with mixed estimation techniques in a number of recent studies of the financial sector. They may well be necessary in the present context to make quarterly models more useful for policy purposes.

The second major issue that I shall address is whether investment is or has been "surprisingly" weak. The answer could well depend on one's preferred specification because that serves as a standard for evaluating actual investment. To the extent that one's preferred specification depends on forecasting performance, there is some built-in bias toward the conclusion that investment is on track. Put another way, it is important that the degree of surprise be evaluated relative to the information available prior to the forecast period.

As indicated earlier, for equipment the two leading candidates would be the accelerator and the modified neoclassical model. According to both models, from mid-1973 to about mid-1975, investment was surprisingly strong. Thereafter the models diverge; the accelerator tracks actual investment reasonably well through mid-1977 but indicates some weakness of investment demand over the last year and a half of the forecast period. The modified neoclassical model substantially overpredicts equipment investment from mid-1975 to mid-1977 and thereafter does a creditable job of tracking the actual path. As noted earlier, Clark interprets this evidence as suggesting that equipment was roughly on track, although an alternative interpretation, based on the modified neoclassical model, would be that actual investment was weak from mid-1975 to mid-1977 and on track thereafter.

For structures the issue is more clear-cut because all the specifications systematically overpredict actual investment in the post-1973 period. While it seems plausible to conclude that investment in structures has been unusually low in the forecast period (the only exception being the modified neoclassical model for 1978), even this judgment is slightly suspect. The reason is that none of the five models for structures does a particularly good job, even within the sample period, so no fully satisfactory standard of comparison is available.

Clark sheds some more light on the shortfall by analyzing disaggregated data on investment. When this is done, commercial structures appear to be the primary source of the shortfall, although whether one judges this component to be surprisingly low depends on providing a suitable equation to explain it. This has not been done successfully so it remains an open issue. And the disaggregated approach cuts both ways. For example, some writers have pointed to a burst of noncapacity-creating investment in pollution equipment. It might then turn out that equipment investment, excluding this category, is weaker than expected. Although this particular breakdown is not analyzed, Clark finds a similar problem when he separates cars and trucks from other equipment investment; equipment excluding cars and trucks does appear weak. Data problems suggest this may be a red herring, but the general point should be clear. Namely, once one starts disaggregating, conclusions based on aggregate data may be reversed.

While I have presented a number of quibbles with Clark's paper, I should like to repeat that he has done an extremely careful job and has given those concerned with investment behavior much food for thought.

Peter Clark: Alan Greenspan correctly emphasizes the interdependence of investment in equipment and structures. It is not clear, however, that this interdependence makes much difference in the empirical results. For each of the five models, the explanatory variables for equipment and structures are nearly the same. If they were identical, and no adjustment for autocorrelation had been used, the coefficients for each explanatory variable in the aggregate equation would be exactly the sum of the coefficients for that variable in the separate equations. And the forecast from the aggregate version would be precisely the sum of the forecasts from the separate equations. Because the explanatory variables are not quite identical, and an autocorrelation correction was used, the exact relation does not hold. But it is a good approximation; for each of the five models an aggregate equation holds no surprises in terms of coefficients and forecasts.

To be sure, an aggregate "additive" equation would fit much better than the separate equations in the event of "offsetting errors." That would be the case if, for any particular model, the residuals for equipment and structures had a strong negative relationship. However, I do not find such a relationship: the correlation between residuals from the equipment and structures equations is close to zero in all five models.

Although a combined equation typically indicates that total investment is below predicted values for 1974–78, the deviation is not significant. By contrast, separate equations for equipment track fairly well for the past five years, while those for structures overpredict significantly. Thus the separate equations reveal that almost all the weakness in nonresidential fixed investment can be attributed to the structures component. In addition, the equations for structures generally show that the standard investment models have very low explanatory power for that area. These conclusions would not have been evident if I had estimated equations only for the total of business fixed investment.

In addition, I should like to comment on the feeling of economists in general, and Greenspan and Goldfeld in particular, that a model which does not include factor prices is somehow unscientific. On the contrary, there is a long tradition in the physical sciences of using different approximations in models designed to explain the evolution of systems during different periods of time. Thus the equations used to explain the short-term pulsations of a star are very different from those that explain its evolution over billions of years from a contracting cloud of gas to a white dwarf. Analogously, my analysis indicates merely that prices have evolved slowly enough over the past thirty years that they do not help to explain the cyclical variation of business fixed investment.

General Discussion

Several participants considered why the cost-of-capital variable had performed so poorly. Martin Feldstein argued that the measure of the cost of capital used by Clark might bear little resemblance to the truly relevant measure. For one thing, the weighting of bonds and stocks seemed arbitrary. Second, the real interest rate variable did not take account of the fact that the tax laws allow the deduction of the full nominal cost of borrowing. A real interest rate that results from a high nominal rate associated with a high inflation rate may have different effects from the same real rate derived from a lower nominal interest rate and a lower inflation rate. Even more fundamentally, Feldstein expressed a lack of faith in any single composite variable for the cost of capital, which presumed identical responses to changes in all components. He mentioned, for example, that he had found different investment responses in British data to equivalent changes in investment tax credits, depreciation allowances, and interest rates.

James Duesenberry recalled that investment studies have generally found some utilization variable or output-growth variable to be dominant. Often some financial variable helps, too; but the auxiliary variable that does best seems to change. He did not find this surprising, however, as actual investment behavior is likely to change. Sometimes corporations use higher hurdle rates of return because of perceived cyclical risks; at times, those firms are especially concerned about their stock prices; at other times, they worry most about their debt position. It may be impossible to obtain stable, consistent results from any particular financial variable. But that did not mean that investment was driven merely by a mechanistic acceleration principle. Duesenberry urged that the considerations that go into capital budgeting in industry should be studied carefully by economists looking for insight in this area.

Franco Modigliani described past findings, which reported that the addition of a cost-of-capital variable significantly improved the results of a pure accelerator formulation. He suspected that Clark's negative findings on this issue reflected differences in specification and thus were not a valid contradiction of the previous results.

Robert Hall offered a different interpretation of Clark's results on the cost of capital. He felt that the equations in the paper suffered severely from problems of simultaneity or two-way causation. Clark considers the line of causation leading from lower interest rates to higher investment. But another line leads from an exogenous rise in demand that increases investment to higher interest rates. The latter route would account thus for the finding of a strong positive relationship between output and investment and of no negative relationship between interest rates and investment. Robert Gordon suggested that the two directions might be disentangled by identifying fiscal and monetary policy changes that should have shifted either the *IS* or the *LM* curve. Clark noted that his application of the Sims test had determined that simultaneity was not a serious problem. Gordon pointed out, however, that the Sims test related future investment to current output, but there is a contemporaneous relationship between investment and output because investment is part of GNP. Gordon suggested fitting a modified accelerator model that related business fixed investment to GNP *excluding* such investment. Modigliani objected that such an equation would not be freed from the effect of investment on consumption and moreover would be a misstatement of the accelerator theory. Clark felt that Hall and Gordon had exaggerated the simultaneity problem and reminded the group that nonresidential fixed investment is only part of the U.S. capital market.

William Nordhaus defended Clark's basic approach, commenting that more work of this type should be done to sort out the performance of alternative theories. He was concerned that some of the critics were too quick to offer theories to eliminate empirical findings they did not like. Nordhaus added that Clark's finding of a low elasticity of substitution was particularly striking. Yet he recalled that several other studies had obtained similar results, in sharp contrast to the assumption of the "neoclassical" model. Indeed, Nordhaus suggested that the low estimate was a typical result of studies that examined this parameter carefully, either in investment equations or in production functions.

Modigliani noted that the weakness of the stock market (and the resulting high value of the dividend-price ratio) depresses the current investment forecasts of any equation that emphasizes the value of securities or the cost of capital. From that point of view, there is a genuine mystery of why investment is so *high*. He offered the conjecture that the stock market is low because buyers of securities compare the earnings-price ratio on equities with the nominal (rather than the real) rate of interest on bonds. Meanwhile, corporate executives may be capitalizing the *prospective nominal* stream of returns from investment projects by the earnings-price ratio, thereby preventing any severe adverse impact of depressed stock prices on capital spending.

James Tobin agreed that theories using rates of return and market values of securities had problems explaining the strength of current investment. He noted, however, that although empirical specifications used the average value for Q, the theory focused on marginal Q. In recent years a number of factors may have raised the return at the margin relative to average profit rates. For example, pollution investments are obligatory and therefore have a high implicit profit rate, even if they do not show up that way in the valuation of the stock market. Similarly, new investment related to energy might exceed past investment in its profitability.

Several panel members suggested alternative specifications that might improve the understanding of investment demand. Elaborating on a theme introduced by Greenspan, Charles Holt called attention to the substantial lag between investment decisions and actual capital outlays. The latter outlays are really a weighted average of decisions made over an extensive period in the past. That argued for a two-stage modeling of the process that explained orders in one equation and then related expenditures to orders in a second. Hendrik Houthakker felt that disaggregation by industry might be fruitful. And Dwight Jaffee suggested that greater disaggregation was required to explain the structures puzzle. Jaffee noted that various types of structures were influenced by different factors: office buildings by vacancy rates, commercial structures by certain demographic variables and retail sales, hospitals by government grant programs, and schools and religious buildings by other demographic elements. He also emphasized the need to pay more attention to considerations on the supply side that influence the resources available in the construction industry and hence its capacity output.