CHARLES W. BISCHOFF
Yale University

Business Investment in the 1970s: A Comparison of Models

THE INVESTMENT BOOM THAT PERSISTED throughout the late nineteen-sixties is now over. Whether private spending for fixed capital, after allowance for rising prices, will increase at all in 1971 is an open question at this point. This paper attempts to supply an answer and to look a bit further ahead, into 1972 and early 1973.

In order to do this, a variety of different models is presented and projected into the future. This is necessary because to date no consensus has developed among economists about the determinants of investment (here taken as private expenditures on nonresidential fixed capital—plant and equipment) or about the magnitude and timing of the effects of monetary and fiscal policies on this aggregate. As Arthur Okun has pointed out:

> The best example I can offer [of a purely scientific, nonideological controversy among economists] is the disagreement among students of business investment regarding the relative importance of internal cash flow, the cost of external capital, and the growth of final demand as determining factors.[1]

This paper also extends the preliminary attempt to explain the behavior of investment spending in 1969–70 that I reported on a year ago.[2]

Many models of investment behavior have been advanced, but only a few

1. Arthur M. Okun, *The Political Economy of Prosperity* (Brookings Institution, 1970), p. 19.
2. Charles W. Bischoff, "Plant and Equipment Spending in 1969 and 1970," *Brookings Papers on Economic Activity* (1:1970), pp. 127–33.

researchers have attempted to compare them systematically.[3] The work reported here is confined to a very high degree of aggregation, which severely limits the possibility of sharp discrimination between models. I can hope only to highlight the range of disagreement and perhaps more important, to suggest the extent to which it leads to different policy prescriptions. This paper presents empirical characterizations of a number of points of view and reports (a) how well they explain the investment experience of the post-Korean era, with particular emphasis on 1969 and 1970; (b) the extent to which the models differ with respect to the way monetary and fiscal policies affect investment, and the extent to which these differences are essential and economically important; and (c) what the models have to say about capital spending prospects over the next two or three years, given several alternative scenarios for the path of the economy as a whole.

The Models

Five different sets of equations explaining investment behavior are presented and applied in this paper. This selection is representative of five theoretical positions on the demand for fixed capital goods. In each case I have separated investment in equipment from investment in nonresidential structures, primarily because the tax policies applied to these two types of asset have diverged greatly in the past few years. Other factors differentially affecting plant spending and equipment spending, such as the price deflators for the respective aggregates, have also moved very differently.[4] Except in one case, however, the form of the equation is the same for both plant and equipment.

3. Prominent studies involving systematic comparisons include Dale W. Jorgenson, Jerald Hunter, and M. Ishag Nadiri, "A Comparison of Alternative Econometric Models of Quarterly Investment Behavior," *Econometrica*, Vol. 38 (March 1970), pp. 187–212; Jorgenson and Calvin D. Siebert, "A Comparison of Alternative Theories of Corporate Investment Behavior," *American Economic Review*, Vol. 58 (September 1968), pp. 681–712; and Edwin Kuh, *Capital Stock Growth: A Micro-econometric Approach* (Amsterdam: North-Holland, 1963).

4. The price deflators for any given quarter are taken as predetermined, implying that, at least for the current period and for the range of demands likely to be encountered, supply is infinitely elastic at the given price. With this proviso, all of the equations can be treated as proper demand equations. In the simulations of the future, these prices are based on price forecasts from a complete econometric model, in which the prices depend primarily on unit labor costs or wages and on price indexes for the economy as a whole, but also partially on the share of investment in total output, with a distributed lag starting two quarters back.

For three of the equations, two from one model and one from another, I present an alternative version, which incorporates capital gains, a factor not included in the standard equations. The three additional equations bring the total to thirteen. Although I mention various economists in discussing the rationale behind each of the equations, I must emphasize that the precise formal specification of the equations is solely my responsibility.

THE GENERALIZED ACCELERATOR MODEL

The most venerable model, with antecedents going back at least to J. M. Clark,[5] is based generally on the acceleration principle, which postulates a linear relationship between net investment and changes in output. As modified and generalized by, among others, Chenery, Koyck, Eisner, and Hickman, the model has developed as a general distributed lag relationship involving both changes in and level of output, along with the level of the existing capacity or capital stock.[6] In one of a number of formulations falling within this class, a firm forms expectations about its future output on the basis of the past output (or sales) of the firm itself, the industry to which it belongs, or both. It then makes plans to adjust its capital stock toward the level that would be an optimum for producing the planned output, if this output were to represent a long-run equilibrium. If the adjustment in any given period is not complete, this can be rationalized in terms of the additional costs that the firm would incur if it tried to make a very rapid adjustment, and in terms of uncertainty that future demand will prove to justify the plans.[7]

5. 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. The antecedents go back even earlier. See C. F. Bickerdike, "A Non-Monetary Cause of Fluctuations in Employment," *Economic Journal*, Vol. 24 (September 1914), pp. 357–70.

6. Hollis B. Chenery, "Overcapacity and the Acceleration Principle," *Econometrica*, Vol. 20 (January 1952), pp. 1–28; L. M. Koyck, *Distributed Lags and Investment Analysis* (Amsterdam: North-Holland, 1954); Eisner's work on this subject, going back to 1952, is extended and summarized in Robert Eisner, "A Permanent Income Theory for Investment: Some Empirical Explorations," *American Economic Review*, Vol. 57 (June 1967), pp. 363–90; Bert G. Hickman, *Investment Demand and U.S. Economic Growth* (Brookings Institution, 1965).

7. The formal consideration of these adjustment costs, as well as the costs of adjusting other factors of production, leads to extremely complicated theoretical formulations, and to equations that look quite different from the one I am presenting. The addition of the problem of uncertainty makes the theoretical formulations still more formidable. All of the equations in this paper are intended to approximate models of investment behavior that have actually been applied, and thus I have not considered the theoretically

The idea of a partial adjustment process is common to all of the models presented, and will not be repeated as each model is introduced. The distinguishing feature of the accelerator model is that the determination of the planned capital stock is based only on output, and not on such factors as the cost of capital, the price of investment goods relative to wages, and various features of the tax system. This pure dependence on output may result from technological rigidities that permit only one capital-output ratio for each product. On the other hand, the model may perform well relative to other models, not because of such technological rigidities, but because the other models are deficient in specifying the precise way in which other factors determine the optimum capital-output ratio.

The model is completed by the assumption that replacement investment is proportional to existing capital stock, or planned output, or some function of the two. The demands of the individual firms are summed to obtain demand at the industry or economy-wide level. Differences in the capital-output ratio among firms or industries will introduce the possibility of aggregation error.

Although few economists would consider them complete representations of the investment process, models of this sort have been tested against a greater variety of data than have any of the others under discussion, and they have generally performed well. Many forecasters use this model as at least one element in their predictive equations, but they usually modify it by adding other variables, including interest rates, cash flows, and variables designed to incorporate the effects of tax policies.

The mathematical statement of the generalized accelerator model that I shall use is shown as equations (1) and (2) in Table 1.

THE CASH FLOW MODEL

A variety of theoretical considerations have been presented for focusing on profits or cash flow as a determinant of business investment. Current and past profits may be thought of as a good proxy for future profit expectations, which in turn determine investment.[8] Given the changes in tax

superior but practically cumbersome models currently under development. The most cogent discussion of the importance, as well as the difficulty, of theoretical research in this area is in Marc Nerlove, "On Lags in Economic Behavior" (the Second Henry Schultz Memorial Lecture, presented to the Second World Congress of the Econometric Society, Cambridge, England, September 8–14, 1970; processed).

8. See, for example, the development of such an equation in Model I of Lawrence R. Klein, *Economic Fluctuations in the United States, 1921–1941* (Wiley, 1950).

Table 1. Investment Equations of Five Econometric Models

Generalized Accelerator Model

(1) $$I_{E,t} = b_0 + \sum_{i=1}^{n} b_i Q_{t-1} + b_{n+1} K_{E,t-1} + u_t.$$

(2) Substitute S for E in the two places it appears in equation (1).

Cash Flow Model

(3) $$I_{E,t} = b_0 + \sum_{i=1}^{n} b_i (F/q_E)_{t-i} + b_{n+1} K_{E,t-1} + u_t.$$

(4) Substitute S for E in the three places it appears in equation (3).

Securities Value Model

(5) $$I_{E,t} = \left[b_0 + \sum_{i=1}^{n} b_i (V/qK)_{t-i} \right] K_{E,t-1} + u_t.$$

(6) Substitute S for E in the two places it appears in equation (5).

Standard Neoclassical Model

(7) $$I_{E,t} = b_0 + \sum_{i=1}^{n} b_i (pQ/c_E)_{t-i} + b_{n+1} K_{E,t-1} + u_t.$$

(8) Substitute S for E in the three places it appears in equation (7).

Federal Reserve–MIT–Penn Model

(9) $$I_{E,t} = b_0 + \sum_{i=1}^{n} b_{1,i} (p/c_E)_{t-i-1} Q_{t-i} + \sum_{i=1}^{n} b_{2,i} (p/c_E)_{t-i-1} Q_{t-i-1} + b_{n+1} K_{E,t-1} + u_t.$$

(10) $$I_{S,t} = b_0 + \sum_{i=1}^{n} b_i [(p/c_S)^{0.5} Q_{t-i}] + b_{n+1} K_{S,t-1} + u_t.$$

Alternates

(11) Substitute alternate formulation of c into equation (7).

(12) Substitute alternate formulation of c into equation (8).

(13) Substitute alternate formulation of c into equation (10).

Definition of Symbols

b = all coefficients

c = rental price of capital, defined, for equipment, as

$$q_E(d_E + r)(1 - k_E - wz_E)/(1 - w).$$

For equation (9), the formula for c allows for price expectations, according to the following formula:

$$q_E(d_E + r - \dot{p}/p)(1 - k_E - wz_E)/(1 - w).$$

Table 1 (*Continued*)

For equations (11)–(13), the alternate formulation allows for capital gains due to rises in the prices of investment goods; the formula is as above, except that $\dot{q}_E/q_E$ replaces $\dot{p}/p$.

d = rate of physical depreciation of capital goods
E = used as a subscript to refer to equipment
F = sum of corporate profits after taxes plus corporate capital consumption allowances
I_E = expenditures for equipment, constant prices
I_S = expenditures for structures, constant prices
i = subscript indicating time
K = net capital stock
k = effective rate of tax credit
n = number of periods
p = output price deflator
Q = gross value added of the private business sector
q = investment price deflator
r = rate of discount used to value return from future capital services
S = used as a subscript to refer to structures
t = subscript indicating time
u = serially correlated disturbance representing effect of other, omitted factors influencing investment
V = market value of equities plus corporate bonds
w = corporate income tax rate
z = discounted value of allowable depreciation deductions on a dollar's worth of new investment (including, where appropriate, the requirement that tax credits be subtracted from the depreciation base)

Notes on Statistical Estimation

In all equations, the parameter n is determined by experimentation.

With the exception of equation (9), all equations are estimated with the Almon polynomial distributed lag technique, using a third-degree polynomial with no restrictions. For equation (9), however, the weights have been restricted to taper off to zero in period $t - n - 1$.

The disturbances, u_t, from these equations are assumed to be generated by a first-order autoregressive process, and the following techniques are used in making the estimates reported in Table 2. Consider an equation of the general form,

$$Y_t = b_0 + \sum_{i=1}^{n} b_i X_{it} + u_t.$$

Table 1 (*Continued*)

Formally, the assumption of a first-order autoregressive process implies that

$$u_t = \rho u_{t-1} + e_t,$$

where ρ is a number between $+1$ and -1. If each of the variables, e_t, is normally and identically distributed with zero mean and constant variance, independent of all the X variables, and without serial correlation, and if Y_1 is considered nonstochastic, the technique is justified. Consistent and asymptotically efficient estimates of ρ and of the coefficients $b_0, b_1, \ldots, b_n$, may be obtained by minimizing the sum of squared residuals in the equation

$$Y_t - \rho Y_{t-1} = b_0(1 - \rho) + \sum_{i=1}^{n} b_i(X_{it} - \rho X_{i,t-1}) + e_t.$$

This is conveniently done by trying a variety of values of ρ between -1 and $+1$, forming the "generalized differences" of all the variables for each trial value, and then using ordinary least squares estimation methods.

The values of the Durbin-Watson (DW) statistic reported in Table 2 refer to the residuals from the transformed equations, e_t; if this statistic is very far from 2.0 it is reasonable to conclude that the assumption of a first-order autoregressive process in the original errors is too simple. The next alternative might be to assume a second-order process. It should be noted, however, that with equations like the ones in this paper, all of which have lagged endogenous variables on the right-hand side, even a value of the DW statistic close to 2.0 does not necessarily indicate that the transformation has removed all of the serial correlation.

treatment of depreciation, profits plus depreciation might provide a better measure. Other theories have emphasized cash flow (profits after taxes plus depreciation) as a source of funds, arguing that, in the presence of risk and imperfect capital markets, the cost of funds to the firm rises sharply when internal funds are exhausted.[9] As with output, profits or cash flow may be introduced as one of several elements, but even equations based on cash flow alone have been found useful for forecasting investment a few quarters ahead.

The specific formulation I will test is based on cash flow gross of dividends. Whereas most of the other models under discussion are basically

9. This view is developed in James S. Duesenberry, *Business Cycles and Economic Growth* (McGraw-Hill, 1958). Duesenberry stresses cash flow net of dividends (retained earnings plus depreciation) as a source of funds. This is one of several important elements in the theoretical model he develops.

theories of real (price-deflated) investment, the cash flow model is most naturally stated in terms of current dollars. In order to be able to compare this model with the others, which predict investment in constant dollars, I have divided cash flow by the price index for the investment aggregate being explained. The mathematical form of the equation is given as equations (3) and (4) in Table 1.

THE SECURITIES VALUE MODEL

Several theories focus on the market value of a firm as a determinant of its investment. James Tobin has argued that if managers seek to maximize the market value of their corporations, they will add to their fixed capital goods whenever the marginal addition to the firm's market value exceeds the cost of the goods.[10] There are several difficulties in applying such a theory. First, no information is available on the marginal effects on market valuation of increased spending for capital goods. Instead, one can try to measure the average ratio of the market value of existing physical capital—as determined in the stock and bond markets—to its reproduction cost, and hope that the marginal and average ratios generally move together. Second, it is difficult to sort out the market valuation of physical capital from that of the rest of a firm's assets.

In a crude empirical approximation to this theory, I have simply used the ratio of the market value of all existing corporations to the net stock of plant and equipment of the private sector (valued at current reproduction prices). Since this ratio is a scale-free number, I have multiplied it by the stock of the asset in question at the end of the previous period. Inclusion of this stock also allows for replacement. This model is similar to one developed by Yehuda Grunfeld,[11] though his rationale, which emphasizes the role of firm market value as a measure of expected future profits, is some-

10. One place where this theory is summarized is William C. Brainard and James Tobin, "Pitfalls in Financial Model Building," American Economic Association, *Papers and Proceedings of the Eightieth Annual Meeting, 1967* (*American Economic Review*, Vol. 58, May 1968), pp. 99–122. The guiding principle of the securities value model is stated on pp. 103–04: "One of the basic theoretical propositions motivating the model is that the market valuation of equities, relative to the replacement cost of the physical assets they represent, is the major determinant of new investment. Investment is stimulated when capital is valued more highly in the market than it costs to produce it, and discouraged when its valuation is less than its replacement cost."

11. 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.

what different. The model is stated mathematically in equations (5) and (6) of Table 1.

THE STANDARD NEOCLASSICAL MODEL

Dale Jorgenson, in a large body of work with various colleagues, has developed and applied several closely related models of investment behavior based on his version of the neoclassical theory of optimal capital accumulation.[12] The term derives from the focus on the classical economic theory emphasizing the relative prices of factors of production as a determinant of optimal factor proportions. Several of the other theories represented by models discussed in this paper could just as well be called neoclassical, but Jorgenson's particular version has been applied in so many cases that it has become the standard against which all of the others are measured.

In the Jorgenson model, as in the accelerator model, each firm is assumed to be adjusting towards a "desired" stock of capital. In contrast with the accelerator model, the neoclassical model assumes that the desired stock depends not only on planned output but also on the ratio of output price to the implicit rental price of the services of capital goods. Jorgenson also assumes that the production possibilities facing each firm are governed by a Cobb-Douglas production function. Given this and several additional assumptions, the "desired" capital stock K^* may be shown to equal $(apQ)/c$, where p is the price deflator for output, c is the rental price of the services of capital goods, and a is the elasticity of capital stock in the production function.

The formula for c, shown in Table 1, and the particular empirical specification I use of the statistical series that go into calculation of c are derived from Jorgenson's work with Robert E. Hall.[13]

The basic equations for the standard neoclassical (SNC) model are shown

12. The theory underlying this model is stated most fully in Dale W. Jorgenson, "The Theory of Investment Behavior," in Robert Ferber (ed.), *Determinants of Investment Behavior*, A Conference of the Universities-National Bureau Committee for Economic Research (Columbia University Press for the National Bureau of Economic Research, 1967). Jorgenson's voluminous empirical work with this model begins with "Capital Theory and Investment Behavior," *American Economic Review*, Vol. 53 (May 1963), pp. 247–59.

13. Robert E. Hall and Dale W. Jorgenson, "Tax Policy and Investment Behavior," *American Economic Review*, Vol. 57 (June 1967), pp. 391–414. Hall and Jorgenson, "Application of the Theory of Optimum Capital Accumulation," in Gary Fromm (ed.), *Tax Incentives and Capital Spending* (Brookings Institution, 1971).

as equations (7) and (8) in Table 1. Equations (11) and (12) reflect an alternative formulation, which has been applied by Jorgenson and Siebert, that takes into account capital gains due to rises in the price of investment goods.[14] In a period of rapid inflation, especially for construction, expected price change is likely to be important; the amount of building undertaken now because it will be more expensive later is likely to be significant. There are, however, difficulties in representing empirically the rate of change in prices of investment goods, since it is the *expected* rate of price change that is relevant.[15]

THE FMP MODEL

A somewhat different version of the neoclassical model is used in the Federal Reserve–MIT–Pennsylvania econometric model (hereafter referred to as the FMP model.)[16] The original investment functions for this model were my own work (with a large assist from Franco Modigliani and Albert Ando). Ando, Modigliani, Robert Rasche, and Stephen J. Turnovsky have subsequently derived a more general theory for the equipment equation.[17] The equations used here are a slightly simplified version of those used in the model; the principal difference is that here I predict equipment expenditures directly in a single relationship instead of first predicting equipment orders and then predicting expenditures on the basis of orders, as the model does.

In contrast to the other models presented here, the FMP model treats equipment and construction asymmetrically. Instead of adjusting toward a desired stock of equipment, firms are assumed to adjust toward a desired level of productive capacity, and they respond to a change in output prices

14. Dale W. Jorgenson and Calvin D. Siebert, "Optimal Capital Accumulation and Corporate Investment Behavior," *Journal of Political Economy*, Vol. 76 (November/December 1968), pp. 1123–51.

15. Following Jorgenson and Siebert, I have used $(q_t - q_{t-4})/[0.5(q_t + q_{t-4})]$, but a number of other formulations are at least as plausible. I have, however, retained the Hall and Jorgenson treatment of depreciation for tax purposes, which is theoretically preferable to that of Jorgenson and Siebert.

16. No single reference to the complete, final version of this model yet exists. The fullest discussion of the investment sector is contained in Albert Ando and Franco Modigliani, "Econometric Analysis of Stabilization Policies," American Economic Association, *Papers and Proceedings of the Eighty-first Annual Meeting, 1968* (*American Economic Review*, Vol. 59, May 1969), pp. 296–314. For the theoretical derivation of the equipment equation see Charles W. Bischoff, "The Effect of Alternative Lag Distributions," in Fromm (ed.), *Tax Incentives and Capital Spending*.

17. See their paper, "On the Role of Expectations of Price Changes and Technological Change in an Investment Function" (March 1971; processed).

relative to the rental price of capital by changing the capital intensity not of the entire stock but only of new net or replacement capacity put into place. This model is derived from an assumption about technology: Factor proportions are assumed to be variable only up to the point that new capacity is put into place.[18]

The conceptual form of the equation is:

$$I = (p/c)^*[Q - (1 - d)Q_{-1}]_t^*,$$

where $(p/c)^*$ represents planned capital intensity, $(Q - Q_{-1})^*$ represents planned net additions to capacity, and $(dQ_{-1})^*$ represents replacement. The statistical specification of this relationship, shown in equation (9) of Table 1, incorporates two separate lag distributions, which allow the dynamic impact of changes in the relative prices, interest rates, and tax policies captured in the p/c term to vary substantially from the dynamic impact of the output terms. Essentially, the impact of output here is similar to that in the accelerator model: A rise in output sets off a temporary boom in investment which then tapers off. No such temporary boom occurs in response to a change in any of the variables captured in the p/c term.

This model also differs from the Hall-Jorgenson model in its treatment of the variables determining c, the rental price of capital services. The formula for c is the same as that in equations (7) and (8), but r, the cost of capital, is taken to be a function of the corporate bond yield, the dividend-price ratio, and the expected rate of change of output prices.[19] The weights in this function are derived approximately from previous estimation of this equation.[20]

The equation for nonresidential construction is much closer to the one used in the standard neoclassical model. Apart from the method of computing the cost of capital, the only difference is that the price elasticity of demand for structures is set at 0.5 instead of unity.[21] The structures equation is (10) in Table 1.

18. A simplified example of the theoretical differences between the accelerator, standard neoclassical, and FMP equipment equations is found in Appendix A.

19. The theoretical development of this formula is discussed in Ando, Modigliani, Rasche, and Turnovsky, "On the Role of Expectations."

20. See Appendix B for details on the formulation. In judging the explanatory power of the equation both during and beyond the sample period, this earlier nonlinear estimation must be taken into account.

21. As for the equipment equation, the weights underlying r and also the price elasticity represent previous nonlinear estimates. Tests of a model similar to the equipment equation did not prove successful; the implication is that structures are more flexible than equipment, and that capital intensity can be varied both before and after structures are put into place.

As in the case of the standard neoclassical equations, the consideration of capital gains leads to an alternative formula for the rental price of capital services. This provides an alternative FMP equation for structures, shown as equation (13) in Table 1. I have used the same formula for the rate of change of the investment price deflator described in footnote 15.

Performance and Implications of the Models

The parameters of the five models have been estimated using quarterly data, seasonally adjusted at annual rates, with a sample period encompassing the sixty-four quarters from 1953 through 1968. For the thirteen equations, summary statistics are provided in Table 2. Because the residuals—differences between actual and predicted values—of successive quarters are strongly correlated with one another, a special estimation technique has been used (see Table 1).

As indicated in the rho column of Table 2, nearly all of the equations show high positive serial correlation of the residuals for successive quarters. Thus, with the possible exception of the FMP equipment equation,[22] the excellent fits have been achieved very largely by feeding the last period's error back into the equation.

In the most extreme case, the equipment equation for the securities value model has been estimated using first differences of all the variables. Of course, this kind of estimation is not new or unusual, but projections using a first-difference equation require knowledge of the level of the variable in the previous period. If the actual value for that period is not known, then an estimated value must be used. This means that the total error for an estimate over two periods will consist of the sum of the error in the first period plus the error in the estimated change for the second period.

This accumulation of errors will not be serious if the errors of consecutive periods tend to cancel each other out. On the average, the sum of disturbances e should approximate zero (see note to Table 1). But the further the projection is carried beyond the last observed value of the dependent variable, the larger the variance of the sum of consecutive errors will become.

22. In this case, the lack of apparent serial correlation in the (estimated) residuals does not disprove the assumption of considerable serial correlation in the (true but unobserved) errors. Instead, I believe it may reflect the substantial amount of experimentation that went into the development of this equation. In other words, the estimate of rho for equation (9) is probably biased downwards.

Table 2. Summary Statistics for Five Investment Models

Model	$\bar{R}^2$ [a]	Standard error of estimate $\overline{SEE}$ [a,b]	Coefficient of autocorrelation[c] ρ	Durbin-Watson statistic DW	Number of terms in Almon lag[c] n
	Equipment expenditures				
Generalized accelerator	0.9901	957	0.706	1.86	23
Cash flow	0.9924	841	0.585	1.71	23
Securities value	0.9874	1,016	1.000	1.98	13
Standard neoclassical	0.9893	995	0.801	1.74	13
Standard neoclassical (alternate)	0.9869	1,099	0.864	1.70	15
Federal Reserve–MIT–Penn	0.9931	800	0.251	2.06	21
	Construction expenditures				
Generalized accelerator	0.9611	553	0.849	2.15	23
Cash flow	0.9664	515	0.646	2.09	23
Securities value	0.9630	540	0.930	2.37	13
Standard neoclassical	0.9613	551	0.774	2.02	23
Standard neoclassical (alternate)	0.9579	576	0.885	2.07	15
Federal Reserve–MIT–Penn	0.9733	459	0.663	2.41	17
Federal Reserve–MIT–Penn (alternate)	0.9633	537	0.814	2.21	19

Source: Derived by author. See text for description of models.

a. The "corrected" $\bar{R}^2$ and standard error of estimate are computed using more than the normal correction factor to allow for biases due to (a) the "data mining" involved in choosing the best length of lag, n, and because ρ is estimated; (b) seasonal adjustment of the data; and (c) the fact that several parameters used in deriving the FMP model—parameters affecting the rental variable and the price elasticity of demand—are approximated on the basis of experience gained in previous nonlinear estimation. For these reasons, five extra degrees of freedom were subtracted for the generalized accelerator, cash flow, standard neoclassical, and securities value models; nine subtracted for the FMP equipment equation; and eight for the FMP construction equation. These bias adjustments are at best crude approximations. $\overline{SEE}$ refers to the square root of the estimated variance of e (not u) in the note to Table 1. $\bar{R}^2$ refers to $1 - \frac{\text{Variance estimated for } e}{\text{Variance estimated for } Y}$.

b. Millions of 1958 dollars.

c. See notes, Table 1.

It might be expected, then, that when they are projected several quarters into the future, without the knowledge of errors from previous quarters to provide a correction factor, these equations will not perform as well as they did during the sample period. Since one of the goals of this paper is to provide estimates up to ten quarters into the future, this is not a particularly good omen.

ANALYSIS OF ESTIMATED PARTIAL RESPONSE PATTERNS

In order to understand what the estimated equations imply about the responses of investment to each of its determinants, I have carried out a number of experiments. In each experiment one lagged explanatory variable is changed by a small amount, while all other variables are held constant, and the response of investment in succeeding quarters is traced. These are called partial responses, because if all of the variables were allowed to move freely, the total response in each period might well be either larger or smaller. Table 3 shows the partial responses to a $1 billion rise in output (and the associated estimated rise in cash flow and security value) in the ten basic equations, period by period.

For equipment, the short-run response patterns fall into three categories and so do the long-run magnitudes. According to both the generalized accelerator and FMP equations, a change in output induces a large, temporary investment boom, as capital (or capacity) is adjusted to its new desired level. This temporary peak response reflects the traditional accelerator effect. In both cases the peak response comes about six quarters after the change, and is more than twice the long-run response. Similar accelerator effects are evident in the generalized accelerator, SNC, and FMP construction equations; and for construction, the temporary peak responses are even relatively larger, more than three times the size of the long-run response. The peak effects come a bit later in the SNC and FMP equations (eleven and ten quarters after the change, respectively, compared with six quarters for the generalized accelerator equation).

The SNC equipment equation also shows an accelerator-type response, but it is much weaker and slower than the response in the FMP equipment equation. The reason for this, in my opinion, is as follows: I believe that the SNC equipment equation is basically misspecified, in so far as it assumes that the response of investment spending to a change in relative prices (wages, interest rates, the investment deflator, tax credits, and so on) is the same as the response to a change in output. This assumption is an essential part of the model (see Appendix A), but it may be empirically invalid. If the assumption of identical response patterns is invalid, the SNC equipment equation fails to distinguish an explosive response to output from a gradual response to relative prices. Thus, when the response pattern is statistically estimated for a period in which there is substantial variation in both output and relative prices, the pattern is really a mixture, or average, of two dis-

Table 3. Estimated Short- and Long-Run Responses of Capital Expenditures to a Given Change in Explanatory Variables

Millions of 1958 dollars, quarterly flows at annual rates

Model	Quarters after change											
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*100*
					Equipment expenditures							
Generalized accelerator[a]	0	63	110	144	166	180	186	188	187	183	179	91
Cash flow[b]	0	28	48	63	73	80	85	88	90	92	93	68
Securities value[c]	0	20	44	69	95	118	139	157	171	183	194	[d]
Standard neoclassical[a]	0	38	60	71	76	79	81	85	92	100	110	69
Federal Reserve–MIT–Penn[a]	0	165	181	192	199	201	200	195	189	180	171	97
					Construction expenditures							
Generalized accelerator[a]	0	26	45	59	68	73	75	74	71	66	60	23
Cash flow[b]	0	7	13	18	22	26	29	31	33	34	34	20
Securities value[c]	0	1	8	17	27	37	46	53	57	59	58	[d]
Standard neoclassical[a]	0	13	25	36	46	55	62	68	72	75	77	24
Federal Reserve–MIT–Penn[a]	0	11	23	36	49	60	69	76	81	83	83	19

Source: Author's estimates.

a. Estimated response is based on $1 billion permanent change in business gross product. For all relative prices, estimated values for 1971:1 are used. In percentage terms, and at the 1971:1 value of variables, the changes given in notes b and c are equivalent to this change.

b. Estimated response is based on $155 million permanent change in corporate cash flow.

c. Estimated response is based on $1.26 billion permanent change in market valuation of U.S. corporations.

d. Not computed, for reasons explained in text.

tinct responses. The estimates would tend to show a smaller and less rapid response to output than in fact occurs, but a larger and quicker response to relative prices than actually takes place.

The contrast between the short-run elasticities of equipment spending with respect to output and relative prices, when the estimated lag distributions for the two effects are allowed to differ, is illustrated in Table 4. It compares the short- and long-run responses for the two types of investment determinants in the SNC and FMP models. As the theoretical analysis suggests, the short-run effects of changes in relative prices in the FMP equipment equation are dramatically smaller than the long-run effects. In the FMP construction equation the responses to relative prices are exactly half of the responses to output in the long run, because of my a priori assumption that the long-run elasticity of construction with respect to p/c is one-half. The key point illustrated by Table 4 is that all of the estimated elasticities for the two SNC equations lie between the output and relative price elasticities for the corresponding FMP equations. This is what would be expected if the two types of effects were being confounded.

Table 4. Estimated Short- and Long-Run Elasticities of Capital Expenditures in SNC and FMP Models

	Equipment equations			*Construction equations*		
Quarters after change	*SNC output or relative price elasticity Q or p/c*	*FMP output elasticity Q*	*FMP relative price elasticity p/c*	*SNC output or relative price elasticity Q or p/c*	*FMP output elasticity Q*	*FMP relative price elasticity p/c*
0	0.000	0.000	0.000	0.000	0.000	0.000
1	0.419	1.535	0.000	0.439	0.559	0.280
2	0.658	1.691	0.152	0.856	1.219	0.610
3	0.778	1.796	0.272	1.239	1.909	0.955
4	0.832	1.855	0.367	1.591	2.567	1.284
5	0.858	1.875	0.441	1.899	3.147	1.573
6	0.884	1.862	0.497	2.149	3.636	1.818
7	0.930	1.822	0.539	2.350	3.998	2.000
8	1.000	1.761	0.569	2.505	4.238	2.119
9	1.094	1.683	0.593	2.608	4.359	2.179
10	1.203	1.593	0.610	2.658	4.362	2.181
Long run	0.757	0.902	0.902	0.843	0.991	0.496

Source: Author's estimates. These elasticities are calculated using 1970:3 values of Q and p/c, and 1970:3 initial conditions.

The second type of response pattern shown in Table 3 is the one indicated for the cash flow equations. Here too the investment response temporarily exceeds its long-run value. The overshooting is relatively moderate, however, and the peaks come relatively late (for the equipment equation, not for five years; for the construction equation, after eleven quarters). As was mentioned earlier, there are several theoretical justifications for a model of investment based on profit-type variables. If the preferred theoretical argument is that cash flow variables determine a "desired" capital stock (as in the accelerator theory), the observed overshooting of investment in response to incremental cash flow can be interpreted in the same way that it has been interpreted in the output-based models.

The third type of response pattern indicated in Table 3 is the response of investment to a change in the market value of outstanding bonds and equities. These responses start out slowly but build up to a rather high level, especially after the first year. No constant long-run responses can be computed for these equations, since they have neither a static equilibrium nor a stable dynamic equilibrium along a path characterized by a constant rate of growth. This lack of equilibrium properties raises severe doubts about the value of the equations in any long-term projection, but the short-run results are nevertheless of some interest. The response of equipment investment to a change in market value is still increasing after ten quarters while the construction response peaks after nine quarters. Because the lag distributions contain large responses in the second and third years after a change, predictions from this model show current investment responding sluggishly at first and very powerfully later to a change in market value of outstanding securities.

In addition to output, a number of fiscal and monetary policy variables are included by the SNC and FMP equations in the terms representing the rental price of capital services. Table 4 gives the short- and long-run partial response of investment to changes in p/c, expressed as a percentage of the investment that would otherwise take place. The effect of any particular fiscal or monetary variable also depends on how much it changes p/c. In Table 5 I have listed the long-run partial elasticities of investment spending with respect to a number of possible policy variables. To determine the approximate short-run response of investment to any variable affecting p/c one need only multiply the long-run percentage shown in Table 5 by the ratio of the short- and long-run responses shown in Table 4. Thus, Table 5 shows that, according to equation (9), a 10 percent fall in the industrial

Table 5. Estimated Long-Run Partial Elasticities of Capital Expenditures in SNC and FMP Models

	Equipment equation		Construction equation	
Variable	*SNC*	*FMP*	*SNC*	*FMP*
Output	0.757	0.902	0.843	0.991
Price of output	0.757	0.902	0.843	0.496
Price of investment goods	−0.757	−0.902	−0.843	−0.496
Bond yield	0.000	−0.360	0.000	0.000
Rate of expected price change	0.000	0.161	0.000	0.000
"Real" bond yield	0.000	−0.198	0.000	0.000
Dividend yield	0.000	−0.164	0.000	−0.346
Corporate tax rate	0.114	−0.392	0.138	−0.226
Depreciation life of asset	−0.139	−0.169	n.c.	n.c.
Rate of tax credit	0.061	0.068	n.c.	n.c.

Source: Author's estimates. All elasticity calculations are made using 1970:4 values of all relative prices, except in the case of the tax credit, for which an effective rate of 5 percent was assumed, although no credit was in effect at that time. Values for other monetary and fiscal variables were: bond yield 0.0822; rate of expected price change 0.0453; real bond yield 0.0369; dividend yield 0.0337; corporate tax rate 0.48; depreciation life for equipment 13.1; depreciation life for structures 22.8.

n.c. Not computed.

corporate bond yield (corresponding in 1970:4 to a drop of 82 basis points) eventually increases investment in equipment by about 3.60 percent (since the elasticity in the long run is −0.360). Table 4 shows that the decline in the bond yield will produce no increase in expenditures until two quarters after the change and then will stimulate equipment spending by about 0.61 percent (3.60 times 0.152 divided by 0.902) in the second quarter, 1.09 percent (3.60 times 0.272 divided by 0.902) in the third quarter, and so forth. The eventual increase will be approximately 3.60 percent, provided the expected rate of change of output prices remains constant so that the entire decrease shows up as a decrease in the "real" interest rate. If the expected rate of change of output prices declines by a similar amount, there will be no long-run effect of the decrease in the bond yield.

The FMP equations use market yields on bonds and equities to determine the discount rate used by firms to evaluate investment projects. As Table 5 shows, most of the elasticities of p/c with respect to these yields are substantial.[23] It is true that these elasticities have not been directly estimated in this paper, and this raises some doubt about the validity of the specific numerical values.[24]

23. The exception is the bond yield in the structures equation. In free estimation its coefficient ran up against the constraint that it could not be negative.

24. For instances in which the responses have been freely estimated, see Ando and

In contrast, however, the discount rate in the SNC equations is a constant *before* taxes; businessmen are assumed to aim always for a 20 percent pretax return; their target rate of return *after* taxes thus declines when the tax rate rises. This explains the "wrong" signs on the corporate tax rate for both SNC equations. The partial effect of a tax rise in lowering the required after-tax discount rate swamps all other effects of the tax rate on p/c. The FMP equations, however, show substantial negative partial impacts of higher profits taxes on investment.

Extrapolation of the Equations to 1969 and 1970

As a test of the ability of the equations to predict beyond the sample period, I have extrapolated all except the securities value equations eight quarters beyond the last sample point, with no error corrections. In addition, the lagged capital stock variables in each equation are generated from the past predictions. The results of this extrapolation or "dynamic simulation" are shown in Table 6.

This test of tracking ability in 1969 and 1970 produces mixed results. The root-mean-square errors are generally larger than the standard errors of estimate during the sample.[25] In view of the serial correlation, as noted above, this is to be expected. The peak in 1969:4 is correctly projected by three of the equipment equations, from the FMP, generalized accelerator, and SNC models. The simulation using the FMP equipment equation does extremely well for five quarters, then moves downward in 1970 more sharply than the actual series.[26] In addition to mirroring the downward movement of business output after 1969:3, this movement reflects the delayed effect of the 1969 removal of the 7 percent investment tax credit on equipment expendi-

---

others, "On the Role of Expectations," for equipment, and Charles W. Bischoff, "Investment Behavior: A Model of Nonresidential Construction in the United States," in American Economic Association, *Papers and Proceedings of the Eighty-Second Annual Meeting, 1969* (*American Economic Review*, Vol. 60, May 1970), pp. 10–17, for construction.

25. The-root-mean-square errors are computed on the basis of eight observations for construction, but only seven for equipment, because equipment spending was artificially depressed in 1970:4 by the automobile strike.

26. The good performance is partly illusory, since Ando, Modigliani, Rasche, and Turnovsky, while fitting their equations only through 1968, did examine their effects on preliminary predictions in 1969 and 1970.

Table 6. Actual Investment and Simulation of Six Alternative Investment Models, 1969–70[a]

Billions of 1958 dollars, at seasonally adjusted annual rates

Year and quarter	*Actual*	*Generalized accelerator*	*Cash flow*	*SNC*	*SNC (alternate)*	*FMP*	*FMP (alternate)*
			Equipment expenditures				
1969:1	55.4	54.4	52.3	54.3	56.1	55.5	[b]
2	57.0	54.8	52.6	54.7	57.5	56.6	[b]
3	57.3	55.2	52.8[c]	55.0	58.7	56.9	[b]
4	57.8[c]	55.4[c]	52.3	55.1[c]	60.1	57.4[c]	[b]
1970:1	56.5	55.3	51.7	54.9	61.1	56.5	[b]
2	56.7	54.5	50.5	54.0	62.3	54.8	[b]
3	56.9	53.8	49.5	53.6	63.4[c]	53.9	[b]
4	54.5	52.9[d]	46.6[d]	53.9[d]	62.6[d]	52.9[d]	[b]
Mean error[e,f]	...	2.0	5.1	2.3	−3.1	0.8	[b]
Root-mean-square error[e,g]	...	2.1	5.3	2.4	3.8	1.4	[b]
			Construction expenditures				
1969:1	23.8	23.5	22.2	24.0	23.1	24.0[c]	23.2
2	23.1	23.7	21.9	24.1[c]	23.8	23.9	24.0
3	24.6[c]	23.8	21.6	24.0	24.4	23.7	24.9
4	24.3	23.9[c]	21.2	23.8	25.2	23.3	25.9
1970:1	24.4	23.8	20.8	23.5	25.8[c]	22.7	26.9[c]
2	23.5	23.5	20.3	23.1	24.7	21.8	25.6
3	22.6	23.2	19.8	22.6	24.0	20.5	24.2
4	21.8	23.1	19.4	21.9	23.6	19.4	23.4
Mean error[f]	...	0.0	2.6	0.1	−0.8	1.1	−1.2
Root-mean-square error[g]	...	0.7	2.7	0.5	1.1	1.5	1.6

Sources: Actual values, *Survey of Current Business*, Vol. 50 (July 1970), p. 8; and Vol. 51 (February 1971), p. 9. Simulated values are from the equations described in the text.

a. No corrections have been made for errors.

b. No alternate is given for the FMP equipment equation because the original equation includes price expectations.

c. Peak. For the cash flow construction equation, the peak comes before 1969:1.

d. No correction was made for the effect of the automobile strike.

e. Mean and root-mean-square errors are calculated using only seven observations.

f. Average of actual minus predicted values.

g. Square root of average squared errors.

tures.[27] In quantitative terms the drop in output is the most important determinant of the decline in predicted values, and the generalized accelerator equation, which depends only on output and is the second-best predictive equation, also reflects the decline.

For construction, the standard neoclassical and generalized accelerator equations provide the best extrapolations. The SNC equation, except for a prediction of the 1969:3 peak that is one quarter too early, catches the movement of the actual series extremely well. The accelerator equation also tracks construction quite well in the projection period.

The performance of the two cash flow equations, in contrast to that of the three models in which output plays a major role, is definitely inferior. This is unexpected because these two equations provided the second-best explanation in the sample period for both equipment and structures. Both of the cash flow equations underpredict badly throughout 1969–70. The lower projections from these equations are a result of the fact that the share of corporate profits in output has been unusually low recently.[28] In trying to distinguish between output-based and profit-based investment theories, researchers in the past have been plagued by the very close relationship between profits and sales. The profit share was exceptionally depressed in 1969–70, even when the decline in output is taken into account. These years provide a situation in which the correlation is broken, and in this one instance, the results do not seem to support the profit-based model.

To complete the discussion of the results in Table 6, the three "alternate" equations, which build expectations of capital gains into the rental price of investment goods, must be considered. The estimated standard errors for these three equations shown in Table 2 are larger than the standard errors

27. I assume that the depressing effect of the tax credit removal essentially started not when it was announced but only when it was passed. In making this assumption I have heeded the argument of Saul Hymans, made in response to an earlier draft of this paper, that the tax credit parameter cannot be set precipitately to zero starting in the second quarter of 1969. Although the administration's intention to seek permanent repeal of the tax credit was announced April 21, 1969, and the repeal was eventually made retroactive for all equipment ordered after April 18, it was not passed until December 1969. There was a large bulge in orders in the months between announcement and passage, which affected expenditures into 1970. A previous temporary repeal had affected only equipment ordered more than a month after announcement. By only gradually reducing the credit parameter to zero, following the lead of Hymans, I have taken account of business skepticism about the passage and effective date of the repeal.

28. See Arthur M. Okun and George L. Perry, "Notes and Numbers on the Profits Squeeze," *Brookings Papers on Economic Activity* (3:1970), pp. 466–72.

for the corresponding equations that ignore capital gains. For the dynamic simulations of the 1969–70 period shown in Table 6, these equations also produce results inferior to those from their counterpart equations. In all simulations these three equations generally overpredict investment; this is especially noticeable for the alternate SNC equipment equation, which produces extremely buoyant predictions. It is somewhat frustrating that these equations do not seem to perform, because, in theory at least, capital gains should not be ignored. It is likely that the specification used is too naïve and does not capture whatever expectations are really held about the degree to which expected future increases in prices make current investment more desirable.

The securities value equations, in contrast to the others, have been simulated for 1969–70 in first-differenced form. This is appropriate because the equipment equation was estimated using first differences and the construction equation, with an autocorrelation coefficient of 0.930, was estimated on data that were very close to being first differenced. The results are given in Table 7. Both securities value equations generally overpredict, with the estimated peaks coming one quarter late. The root-mean-square errors and

Table 7. Simulation of Securities Value Equations in First-Differenced Form, 1969–70

Billions of 1958 dollars, seasonally adjusted annual rate

	Equipment expenditures		*Construction expenditures*	
Year and quarter	*Actual*	*Predicted*	*Actual*	*Predicted*
1969:1	55.4	58.7	23.8	24.8
2	57.0	60.3	23.1	25.8
3	57.3	61.1	24.6[a]	26.4
4	57.8[a]	60.9	24.3	26.5[a]
1970:1	56.5	61.2[a]	24.4	26.2
2	56.7	61.1	23.5	25.6
3	56.9	58.7	22.6	24.4
4	54.5	56.0[b]	21.8	22.7
Mean error[c]	...	−3.5	...	−1.8
Root-mean-square error[d]	...	3.6	...	1.9

Sources: Same as Table 6.
a. Peak.
b. No correction for the effect of the automobile strike was made. For equipment this observation was excluded from the calculation of mean error and root-mean-square error, which are based only on the first seven observations.
c. Average of actual minus predicted values.
d. Square root of average squared errors.

mean errors (in absolute size) exceed those of nearly all other equations. The overpredictions reflect the lagged effects of high values of the ratio of market value to the reproduction cost of capital in 1968, and the substantial lag of four to five quarters before the 1969 downturn of equity values significantly influences the predictions. It is of interest, however, that the errors come close to canceling out over the eight quarters, and by 1970:4 the simulated values are closer to the actual values than they are at any other point in the prediction period.

The general conclusion from these tests is that the three output-based models—FMP, SNC, and accelerator—perform the best, though no one of these is clearly superior to the other two.

The partial response patterns discussed earlier provide some clue to the differing projections for 1969 and 1970. The decline in equipment spending during 1970 projected by the accelerator, SNC, and FMP equations is basically a response to the decline of output from its 1969:3 peak. The smallest decline in equipment spending from 1969:4 to 1970:4—$1.2 billion (annual rate, 1958 prices)—is projected by the SNC equation. It is composed of a small and delayed response to the drop in output and a negative response to the removal of the investment tax credit. The accelerator equation projects a decrease of $2.5 billion, all due to the output decline; the projected drop in investment is larger than that of the SNC equation because the accelerator equation has larger output multipliers in the short run. The FMP equation predicts the largest decline by far—$4.5 billion—since its response to output is fully as big as that from the accelerator equation, and it gives some weight to the removal of the tax credit and the rise in interest rates.

These three equations all project declines in construction spending, again in large part as a response to the drop in output. The accelerator equation ignores the price rises for construction and thus projects only a very small drop. Even though the FMP equation has a price elasticity of only one-half, it still gives the most bearish picture of construction—a $4.6 billion decrease from the 1969:1 peak—because the yield on equities rose 30 percent between 1969:2 and 1970:2. This influence alone would reduce construction investment by about 15 percent within a year. The SNC equation, despite its high price elasticity, produces a projection that is almost on the nose.

The cash flow equations also project declines for constant-dollar spending starting from peaks in 1969:3 for equipment and 1968:4 for construction. These declines mirror the fall in cash flow that began after the 1969:2 peak. In addition, rapidly rising construction prices depress the constant-dollar estimates of construction spending even before cash flow begins to fall.

The movements projected by the securities value equations reflect first the rise in equity and bond values that took place between 1967:4 and 1969:2 and then, with a lag, the decline that continued until the trough in 1970:2. The long lags reflect the response patterns shown in Table 3.

Assumptions underlying Projections

Four types of assumptions and adjustments must be specified before the equations can be used to project future investment. First, the path of overall economic activity must be projected. That projection is not the result of my own work with a complete econometric model. Instead, I have made a number of assumptions about the paths of output, cash flow, and the value of securities that seem reasonable to me, and then extrapolated the equations based on these assumptions.

Second, the equations must be adjusted to take account of the temporary distortion of investment in autos and trucks, and of the level of output, in late 1970 because of a strike at General Motors.

Third, on January 11, 1971, President Nixon announced his intention to put into effect a new policy with regard to depreciation of all equipment purchased after January 1, 1971. As of this writing, the new rules have not yet been formally promulgated, but some assumption must be made about the outcome of this proposal and about changes in cash flow and the cost of capital that might result.

Finally, the equations require adjustment to take account of the persistence of errors that affected the results in 1969 and 1970.

GENERAL ECONOMIC PATH

The standard set of assumptions about future economic activity corresponds approximately to the "consensus forecast" for the next ten quarters. Real output grows slowly throughout 1971, although there is a big increase in output in 1971:1 due to recovery from the strike at General Motors, and output in 1971:3 is depressed because of the effects of an assumed sixty-day steel strike. The growth rate accelerates in 1972 and 1973. These assumptions correspond to a gross national product in current prices of $1,046 billion in 1971 and $1,137 billion in 1972, or $743 billion and $780 billion, respectively, in 1958 prices.

Inflation is assumed to continue, though at a decreasing rate. The deflator for gross national product rises 3.9 percent between 1970:4 and 1971:4, and 3.1 percent between 1971:4 and 1972:4. Tax rates and government spending are projected at the officially planned levels, and monetary policy is assumed to hold bond yields approximately at their 1971:1 levels (this corresponds to about 5 percent annual growth in the narrowly defined money supply). Thus real interest rates on bonds increase slightly as the rate of inflation (and the expected rate of inflation) gradually decreases.

Corporate cash flow is assumed to grow rapidly in response to the recovery and to the influence of liberalized depreciation policies, as specified below. From the strike-depressed level of cash flow in 1970:4, a rise of 40 percent is projected by 1973:2.

The current stock market recovery is assumed to continue, with Standard and Poor's index of the prices of 500 common stocks rising from its March 1971 level of around 100 to an average of 116 in 1973:2 (1941–43 = 10). This would represent a 46 percent increase from the 79.2 low of 1970:2; it may be compared with the 45 percent increase in equity values in the nine-quarter period 1966:3–1968:4, the 62 percent rise in the fourteen quarters 1962:2–1965:4, and the 74 percent rise in the ten quarters 1953:4–1956:2. A 54 percent rise over the 1970:2 low is projected for the aggregate market value of corporate bonds.

The rates of increase in the price deflators for equipment and construction expenditures are assumed to decline gradually from their current high rates; the assumptions about these deflators differ slightly from projection to projection, as they depend partly on the strength of the demand for the capital goods in question.

Generally speaking, these assumptions are consistent with one another. They have been derived, with some adjustments, from the two most recent forecasts made by Michael K. Evans with the forecasting model of Chase Econometric Associates, Inc.[29]

29. I am grateful to Dr. Evans for supplying the forecasts and granting permission to use them, and for making suggestions on how to adjust his variable definitions to correspond with mine. I have assumed a slightly tighter monetary policy than he has assumed.

STRIKE ADJUSTMENT

A set of adjustments is required in light of the automobile strike of late 1970 and the possible steel strike of 1971, both to smooth the assumed path of output and to correct for the delay in deliveries of equipment, particularly trucks.

The rationale behind the output adjustment is as follows: The auto strike should have virtually no effect on the future investment plans of General Motors. Most of the effects on output are viewed as transitory; this applies to both the depressed levels of the last half of 1970 and to the stimulated levels of the first half of 1971, when previously unsatisfied customers sought accommodation. Thus, the output numbers that influence GM's expectation of future output, on which planned capital stock or capacity is based, should have the values they would have assumed had there been no strike.

Though the precise effect of the sixty-eight-day strike, extending from September 15 to November 23, 1970, is not known, it appears that gross auto product in constant dollars, seasonally adjusted at annual rates, was depressed by about $12 billion in 1970:4.[30] Recovery from the strike, even if not all lost sales are made up, should inflate the annual rate of real business gross product by about $5 billion in each of the first two quarters of 1971. To remove the effects of the strike I have adjusted output by these amounts. Similar adjustments have been made to remove the projected effect of a steel strike.

This adjustment reduces the error in 1970:4 for all equations that include output, and substantially increases projected investment spending in early 1971. Similar adjustments to the cash flow and securities value time series might be appropriate. However, it can be argued that the disturbances to cash flow, though transitory, do constrain in a very real way the money available for investment, dividends, or other uses. As for the stock market, it is virtually impossible to determine how much difference the strike made. To the extent that investors discounted the strike as a temporary aberration, there should be little effect.

The second adjustment is made for the equipment expenditures, especially on trucks, that had to be postponed as a result of the General Motors work stoppage. In addition, most investment by General Motors was ap-

30. The seasonally adjusted numbers published by the Office of Business Economics show little or no effect in 1970:3.

parently delayed during the strike. I assume that all desired purchases in 1970:3 could be made out of dealer inventories, but that $2 billion in real investment was postponed in 1970:4.[31] This was allowed for by subtracting $2 billion from the intercept of all equipment equations in 1970:4 and adding $1 billion in each of the first two quarters of 1971 (assuming that half of the postponed investment took place in each of these two quarters).

THE NEW DEPRECIATION REGULATIONS

I have assumed that the new depreciation regulations will take effect and that no further changes in tax laws will be made. The new regulations involve three changes, all of which have the effect of permitting firms to take depreciation for tax purposes earlier than had previously been allowed: (1) institution of a new depreciation method, called the asset depreciation range (ADR) system, which would allow firms to use tax lifetimes for equipment that, in most cases, are 20 percent shorter than those previously in effect; (2) repeal of the reserve ratio test, which implied that sooner or later firms would have to prove that the lifetimes they assumed for tax purposes were not very different from the economic lifetimes in actual practice; and (3) under the modified first-year convention, permission to firms to treat any equipment they have purchased less than six months before the end of their fiscal years as if they had held it for fully six months, and equipment between six months and a year old as if it were fully a year old.

If, for example, a firm whose fiscal year corresponded to the calendar year purchased a machine for $1,000 in the second quarter, it could deduct in that year, under the old rules, only one-half of the ordinary first year's depreciation allowance. A machine with a ten-year lifetime for tax purposes, eligible for the double-declining-balance depreciation method, would be eligible for a $100 deduction (half of the ordinary deduction for the first full year), and thus the firm would pay $48 less taxes for that year, based on the normal corporate rate.

Under the new rules, the firm will be able to deduct a full year's depreciation, and in addition the machine will now generally have an assumed eight-year service lifetime (regardless of the actual useful lifetime). The full year's deduction will thus rise to $250, and the tax saving will be $120.

Of course, for any one machine later deductions will be smaller, and

31. I base this estimate on oral comments by Alan Greenspan and Michael K. Evans.

thus the reductions are in essence only interest-free loans from the government. But such "loans" are no less valuable than others, and the FMP and SNC models take this into account by including the present discounted value of future depreciation deductions as a factor in the rental cost of equipment. As long as investment rises over time, the increments to corporate cash flow resulting from the additional tax savings in the first few years on new equipment will exceed the opposite effect resulting from lower deductions later on for any given piece of equipment.

I have estimated that, under the new policy, the reduction in Treasury revenues will be $1.6 billion in 1971 and approximately $3 billion in 1973. These estimated reductions (shown in detail in Table 10) are somewhat smaller than those reported by the Treasury Department, because I have assumed that, at least initially, not all firms will take advantage of the tax savings.[32] Using a 48 percent tax rate, I have calculated the effects assuming full adoption of the new rules and 20 percent shorter lifetimes for all equipment, and have then reduced these estimates by 20 percent.[33]

ADJUSTMENT FOR 1970 ERRORS

Adjustments must also be made for incorrect predictions of the models, stemming from sources other than the auto strike, in the quarters immediately preceding the projection period. From a number of methods of adjustment,[34] I have chosen projection of the variables in the first-differenced

32. Other policies that permit accelerated depreciation of capital goods have not been fully adopted by business firms, even many years after their implementation. One example is the accelerated depreciation methods made available in 1954. Allan H. Young has concluded that from 1960 to 1966 only 79 percent of the assets purchased by manufacturers were depreciated under the new methods, and that other business purchasers applied the methods to only 56 percent of their purchases of equipment and 64 percent of their purchases of structures. Allan H. Young, "Alternative Estimates of Corporate Depreciation and Profits: Part I," *Survey of Current Business*, Vol. 48 (April 1968), pp. 17–28.

33. Not all corporations are taxed at this rate, and not all investment is carried out by corporations; these facts also call for reduced estimates.

34. I have also considered the technique of autoregressive adjustment in making the projections. That approach uses the first-order autoregressive process built into the estimation procedure as a means of adjusting for the last observed error. It allows that error to die out gradually in a pattern of geometric decay. The projections for 1971 based on this method are rather close to those using the first-difference technique. In addition, I considered whether a reasonable adjustment could be made on the basis of informed judgment and examination of the 1969–70 residuals. The adjustments already described for the auto strike incorporate as much a priori information as I am willing to use at this

form. It is consistent with the theory that, at least in the short run, the effects of past errors do not die out, and it has been used extensively by practicing forecasters. The advantages have been summarized by Daniel Suits. Three of his reasons for using this method apply in this case:

> . . . In short-run analysis and forecasting, the present position is known, and *ceteris paribus* will continue. The important question is what change from that position will result from projected changes in other factors. . . . The use of first differences minimizes the effect of slowly moving variables such as population, tastes, technical change, etc., without explicitly introducing them into the analysis. . . . Finally, use of first differences minimizes the complications produced by data revision. . . . Revisions usually alter the level at which variables are measured, rather than their year-to-year variation.[35]

It can be shown that the use of first differences is mathematically equivalent to adjusting the intercept of the equation so that it fits perfectly in 1970:4, and then making all projections with this altered equation. In applying this method I have retained the strike adjustments described earlier.

The 1971–73 Outlook for Fixed Investment

The ten basic equations have been projected for the ten quarters from 1971:1 through 1973:2, on the basis of the first-differences technique. These projections use assumptions about the time paths of the determinants of investment that have been outlined above and that are described in greater detail in Appendix C.[36] The projections are listed in Table 8 and plotted in

time. However, the recent and continuing boom in the investment of such regulated industries as electric utilities and communications provides an alternative basis for adjusting the intercept.

I have made several sets of simulations using judgmental intercept adjustments based on such information. In general these simulations are similar to the first-differenced projections; they tend to be somewhat lower because the judgmental adjustments do not raise the estimates quite as much as the intercept adjustment for the 1970:4 errors.

35. Daniel B. Suits, "Forecasting and Analysis with an Econometric Model," *American Economic Review*, Vol. 52 (March 1962), pp. 104–32. Quote is from p. 112.

36. The three alternate equations, which take capital gains on investment goods into account, have also been extrapolated, but the results are totally implausible, as projected expenditures in real terms first swing rapidly upward and then plunge equally rapidly. This is a result of a somewhat unstable response to the initial price expectation terms, which push the projected rental value toward zero. A more sophisticated treatment of capital gains expectations might well remedy this defect.

Table 8. First-Differenced Projections of Capital Investment, Using Specified Assumptions, Five Models, 1971–73

Billions of 1958 dollars, seasonally adjusted at annual rates; numbers in parentheses are percentage changes from previous period

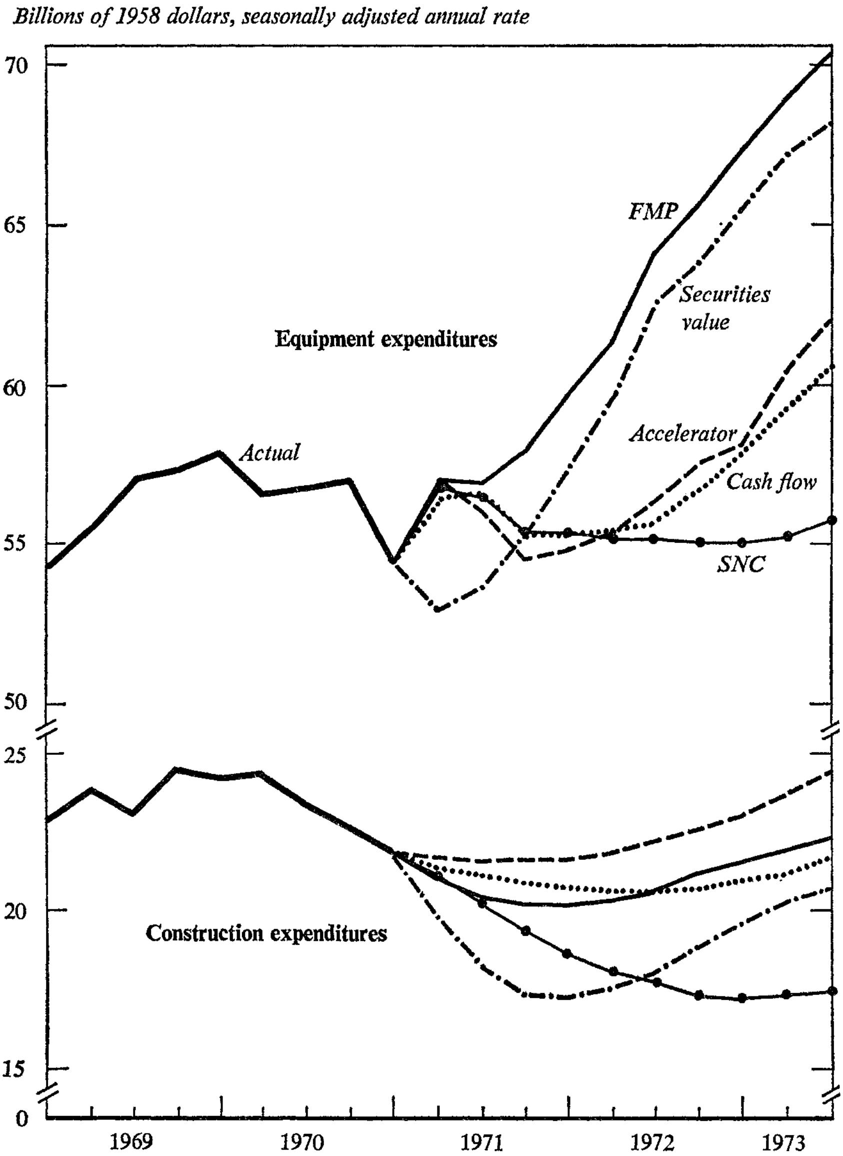
Year and half	Accelerator	Cash flow	Securities value	Standard neoclassical	Federal Reserve–MIT–Penn
			Equipment expenditures		
1971 First	56.3 (+1)	56.4 (+1)	53.3 (−4)	56.6 (+2)	56.9 (+2)
Second	54.7 (−3)	55.2 (−2)	56.2 (+5)	55.3 (−2)	58.8 (+3)
1972 First	55.7 (+2)	55.4 (0)	61.0 (+9)	55.1 (0)	62.7 (+7)
Second	58.2 (+4)	57.2 (+3)	64.6 (+6)	55.0 (0)	66.5 (+6)
1973 First	61.1 (+5)	59.8 (+5)	67.7 (+5)	55.4 (+1)	69.7 (+5)
			Construction expenditures		
1971 First	21.6 (−2)	21.2 (−4)	19.0 (−14)	20.6 (−7)	20.6 (−7)
Second	21.6 (0)	20.8 (−2)	17.2 (−9)	19.1 (−7)	20.2 (−2)
1972 First	21.9 (+1)	20.6 (−1)	17.8 (+3)	17.9 (−6)	20.4 (+1)
Second	22.8 (+4)	20.8 (+1)	19.2 (+8)	17.2 (−4)	21.3 (+4)
1973 First	24.1 (+6)	21.4 (+3)	20.4 (+6)	17.5 (+2)	22.0 (+3)
			Total		
1971 First	77.9 (0)	77.6 (0)	72.3 (−7)	77.2 (−1)	77.5 (−1)
Second	76.3 (−2)	76.0 (−2)	73.4 (+2)	74.4 (−4)	79.0 (+2)
1972 First	77.6 (+2)	76.0 (0)	78.8 (+7)	73.0 (−2)	83.1 (+5)
Second	81.0 (+4)	78.0 (+3)	83.8 (+6)	72.2 (−1)	87.8 (+5)
1973 First	85.2 (+5)	81.2 (+4)	88.1 (+5)	72.9 (+1)	91.7 (+4)

Source: Same as Figure 1.

Figure 1.[37] It is striking that four of the five equations (the exception is the securities value equation, with its long lags) project almost exactly the same path for equipment spending in 1971:1 and 1971:2 (see Figure 1). After this point the paths diverge, although the accelerator and cash flow projections move together, as do the FMP and securities value projections. It is also striking that, whatever the level, these four equations all project a 10 percent rise (annual rate) in equipment spending in the first half of 1973 compared with the last half of 1972. The exception is the SNC equation, which projects an almost completely flat path of real investment from the second half of 1971 to the first half of 1973. As before, it is the weakness of the accelerator effect in this equation, as well as the low long-run output multiplier, that accounts for the pessimistic view.

37. Projected levels as well as percentage changes are shown in Table 8. If the investment data for 1970 are subsequently revised, the levels of all projected variables should be revised by an equal amount.

Figure 1. Capital Expenditures, Actual, 1969–70, Projected, 1971–73



Note: All projections are made using first differences.
Sources: 1969–70—*Survey of Current Business*, Vol. 50 (July 1970), p. 17, and Vol. 51 (March 1971), p. 9; 1971–73—author's estimates.

The cash flow equation for equipment yields a path similar to that based on the accelerator equation. But that result comes about only because the cash flow intercept has been adjusted upward by $10.3 billion to offset its underprediction in 1970:4. Even with this boost the projection shows stagnation between the first half of 1971 and the first half of 1972.

The difference between the accelerator and FMP projections is accounted for by (1) the slightly higher output multipliers in the FMP equation; (2) the effect of the new depreciation rules, which adds $3.0 billion to the FMP projection by 1973:2; (3) a decrease in the nominal industrial bond yield from a high of 8.48 percent in 1970:3 to an assumed level of 7.37 percent in 1972 and 1973;[38] and (4) a decrease in the industrial dividend yield from 0.0337 in 1970:4 (and an earlier high of 0.0392) to an assumed low of 0.0287 in 1972:1 (the effect is damped by an assumed recovery of the dividend yield to 0.0316 in 1973:2).

If anything, I feel I have been conservative in assuming no further drop in corporate bond yields below levels prevailing in March 1971. Also, the projected effect of the new depreciation rules may be conservative in so far as it assumes only 80 percent adoption. The conclusion is that the projection of nearly $70 billion by FMP for the first half of 1973 is not an unreasonably high one. Nevertheless, I am a bit unhappy about the unexplained intercept adjustment of $3.15 billion that underlies this figure. I believe that at least some of this represents transitory errors, and my "best guess" for equipment spending at that stage would be about $68 billion, halfway between the first-differenced and unadjusted projections.

The securities value projection, which bounces back quickly from an unreasonable low in the first half of 1971, reinforces my conclusion. However, given the inevitable uncertainty about a stock market forecast so far in advance, the numbers projected from this equation must be considered highly speculative.

As Figure 1 shows, the projections for construction differ widely. The accelerator projections are the most optimistic. The SNC projections seem clearly too pessimistic, as are the projections for 1971 from the securities value equation. This leaves the cash flow and FMP projections, which are

38. It should be noted, however, that the "real" interest rate falls much less from 0.0417 (that is, 0.0848 minus 0.0431) in 1970:3 to 0.0404 (or 0.0737 minus 0.0333) in 1973.2, as the rate of inflation declines. There is, however, a large temporary stimulus, because the rate of inflation declines only gradually.

close together but seem a bit low. I am convinced that the price of construction does have some negative effect, but not as much as is implied by the equations with unitary price elasticities (SNC, securities value, cash flow). My best guess for the path of construction spending is between the accelerator and FMP paths, implying an annual rate of about $23 billion (1958 prices) for early 1973.

Some of the implications of the projections for outlays in current dollars are reported in Table 9. These numbers are all based on the two FMP equations, as projected in first-differenced form. As indicated above, I feel the equipment projections may be a bit high, especially for the latter part of the period, while the construction projections seem too low. With these caveats, these equations give the results that, to me, seem the most reasonable and the most likely to be realized. The 1971 outlook is for current-dollar expenditures of $106.4 billion, a rise of 3.7 percent above 1970, with the level in 1958 prices at $78.2 billion, a 1.3 percent decline.

Table 9. Actual Investment, 1969–70, and First-Differenced Projections, 1971–73, FMP Model

	Equipment expenditures		*Construction expenditures*		*Total nonresidential fixed private investment*	
Year	*Amount*	*Percent increase*	*Amount*	*Percent increase*	*Amount*	*Percent increase*
			Billions of 1958 dollars			
1969	56.9		24.0		80.8	
1970	56.1	−1.4	23.1	−3.8	79.2	−2.0
1971	57.8	+3.0	20.4	−11.7	78.2	−1.3
1972	64.6	+11.8	20.9	+2.4	85.5	+9.3
1973 (first half)[a]	69.7	+11.1	22.0	+7.8	91.7	+10.2
			Billions of current dollars			
1969	65.5		33.8		99.3	
1970	67.4	+2.9	35.2	+4.1	102.6	+3.3
1971	72.3	+7.3	34.2	−2.8	106.4	+3.7
1972	83.5	+15.5	37.2	+8.8	120.7	+13.4
1973 (first half)[a]	91.3	+13.3	40.9	+13.8	132.2	+13.5

Sources: 1969–70 values, *Survey of Current Business*, Vol. 51 (March 1971), p. 9; 1971–73 values, author's estimates. Details may not add to totals because of rounding.

a. Seasonally adjusted at annual rates. Percent increase shown is for 1973 first half over 1972 first half.

Some Variations on the Projections

In order to explore more fully the implications of the models for the investment outlook in the next few years, I have made several supplementary calculations. One identifies the differences in investment spending between projections that include and those that exclude the new depreciation policies. The second simulation shows the additional investment that would be forthcoming on the basis of a more bullish overall economic outlook consistent with the administration's forecast of GNP for 1971 at $1,065 billion. The third simulation considers the effect of different assumptions about the path of the stock market on the investment projections of the securities value model.

DEPRECIATION

Table 10 records the differences in projected investment that may result from the new depreciation policies. Since the effects are included in the projections reviewed above, the investment amounts shown in the table may be regarded either as the contribution of the new regulations to prospective investment or as the loss of investment that would come about if the regulations are not put into effect. Since both equipment and construction expenditures are affected by cash flow, the calculated effects use both cash flow equations. For the SNC and FMP models, only equipment expenditures are influenced. The accelerator equation is omitted; it would show zero impact by assumption. The SNC equation projects a very prompt and large impact, exceeding the direct revenue loss to the Treasury by 1971:3. The FMP and cash flow equations show smaller and more gradual responses. Nonetheless, by the end of 1972, the direct impacts come very close to the revenue losses for the cash flow equations, and exceed the revenue losses for the FMP equation. These impacts for FMP and cash flow thus also imply a big "bang for a buck" although only after a substantial lag.

The impacts are labeled "direct" because they do not include the secondary, induced effects that would work through changes in incomes, interest rates, and so on, resulting from the initial additional investment. Such effects could be appraised only by using a complete econometric model.

The qualitative character of some of the secondary, complete model effects can, however, be identified. The increases in equipment spending

Table 10. Estimated Direct Revenue and Investment Impact of January 1971 Depreciation Rules, Three Models, 1971–73

Billions of dollars at annual rate

Type of impact and model	Quarterly impacts										Totals			Fiscal year totals		
	1971				1972				1973		1971 year	1972 year	1973 first half			
	1	2	3	4	1	2	3	4	1	2				1971	1972	1973
Direct revenue impact	1.1	1.6	1.8	2.0	2.2	2.3	2.5	2.7	2.8	2.9	1.6	2.4	2.8	0.7	2.1	2.7
Direct impacts on investment																
Cash flow equations																
Equipment	0.0	0.2	0.5	0.8	1.0	1.2	1.4	1.6	1.7	1.8	0.4	1.3	1.8	0.1	0.9	1.6
Structures	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.1	0.6	0.8	*	0.4	0.7
Total	0.0	0.3	0.7	1.1	1.4	1.7	2.0	2.3	2.5	2.7	0.5	1.9	2.6	0.1	1.2	2.4
Standard neoclassical equation (equipment)	0.0	1.5	2.3	2.8	3.0	3.2	3.3	3.5	3.9	4.3	1.6	3.2	4.1	0.4	2.8	3.8
Federal Reserve–MIT–Penn equation	0.0	*	0.7	1.4	1.7	2.1	2.4	2.7	2.9	3.0	0.5	2.2	3.0	*	1.4	2.7

Source: Author's estimates. Details may not add to totals because of rounding.

* Less than $50 million.

should be partially offset by substitution away from structures, although the multiplier-accelerator effects should guarantee that, on balance, construction of nonresidential buildings will rise. Housing should, at least relatively, be hurt.

It does make a difference, however, which one of the models most closely reproduces reality. I find somewhat comforting the fact that, for this policy, the computed effects do not differ by much more than 50 percent by the end of the projection period. I do think the short-run effects computed from the SNC model are too large. The cash flow equations must be considered conservative, and also suspect because the equations performed poorly when projected in 1969 and 1970. I would therefore select the result of the FMP equation as the most reliable projection.

ALTERNATIVE "GOVERNMENT ECONOMIC FORECAST"

An alternative set of simulations has been made, using the widely discussed government forecast underlying the President's budget projection, in which the current-dollar GNP rises to $1,065 billion in 1971. The assumptions for these projections are also derived from a simulation of the Chase Econometrics model. The model attains the higher growth path as a result of increases in the intercepts of the automobile, inventory, and housing demand equations. These adjustments correspond to exogenous increases in demand, and since the adjusted equations are used throughout the simulation period, output is higher in 1972 and 1973 as well. The precise nature of the "government forecast" assumptions is recorded in Appendix C.

Table 11 gives the results of the projections based on these assumptions. For 1971, the various models indicate impacts of $1.0 billion for the accelerator model, $0.7 billion for cash flow, $0.4 billion for SNC, and $1.4 billion for FMP (all in real terms). Clearly the realization of this forecast will depend on the strength of exogenous spending in other sectors; the impetus will not come from investment. In 1972, however, higher growth leads to larger effects. The FMP equation indicates an addition of $3.7 billion in 1972 if, somehow, the 1971 growth target is realized.

ALTERNATIVE STOCK MARKET PROJECTIONS

Two alternative paths for the stock market are assumed and their impacts are calculated using the securities value equations. In the "bearish" set of

Table 11. Additional Investment Projected under "Government Forecast" Assumptions, Four Models, 1971–73

Billions of 1958 dollars, seasonally adjusted at annual rates

Year and half	*Accelerator*	*Cash flow*	*Standard neoclassical*	*Federal Reserve–MIT–Penn*
		Equipment expenditures		
1971 First	0.2	0.2	0.1	0.5
Second	1.3	1.0	0.6	2.0
1972 First	2.2	1.6	0.9	2.8
Second	2.6	1.6	0.9	3.0
1973 First	2.4	1.2	0.9	2.8
		Construction expenditures		
1971 First	0.1	0.0	0.0	0.0
Second	0.5	0.2	0.2	0.3
1972 First	0.9	0.5	0.4	0.6
Second	1.0	0.5	0.5	0.8
1973 First	0.9	0.4	0.5	0.7

Sources: Author's estimates. See Appendix C for "government forecast" assumptions.

assumptions, no increase at all occurs in equity values over the next ten quarters (of course, the market *could* actually decline). In the other alternative, a rise of nearly 63 percent in equity values is assumed between 1970:2 and 1973:2. This rate of increase is exceeded only in the greatest bull market in postwar history, the boom between 1953:4 and 1956:2.

The alternative stock market projections lead to the results in Table 12. The most bullish assumed path pushes equipment spending projected by the securities value equation up to a level higher than that in any other projection, though construction spending is still projected at a lower level than is implied by the accelerator equation.

If the market were in fact to rise this much, the ratio of securities value to reproduction cost of capital would be pushed from its low of 0.910 in 1970:2 to 1.182 in 1973:2.

The uncertainty about these projections must be emphasized. It is clear that the market has already bounced back strongly. The ratio of market values to replacement costs has risen from a low of 0.910 in 1970:2 to 0.961 in 1970:4, and, according to my preliminary figures, 1.050 in 1971:1. The "standard" projection raises this ratio to 1.104 by 1973:2, while in a market with no increases the ratio would decline to 0.994. On the high path it would be 1.182 in 1973:2. The path implied by the high projection would

Table 12. Projections of Investment Spending for Alternative Paths of the Stock Market, Securities Value Model, 1971–73
Billions of 1958 dollars, seasonally adjusted at annual rates

	Movement in 500-stock index[a]		
Year and half	*Remains at 100*	*Rises to 116 in 1973:2*	*Rises to 128 in 1973:2*
	Equipment expenditures		
1971 First	53.3	53.3	53.3
Second	56.2	56.2	56.5
1972 First	59.5	61.0	62.0
Second	61.8	64.6	68.0
1973 First	62.0	67.7	73.4
	Construction expenditures		
1971 First	19.0	19.0	19.0
Second	17.2	17.2	17.2
1972 First	17.6	17.8	18.0
Second	18.5	19.2	20.0
1973 First	18.8	20.4	22.1

Sources: Author's estimates.
a. Standard and Poor Corporation's combined index of 500 stocks (1941–43 = 10).

require an additional rise in the ratio of equity values to replacement costs that is roughly as large as the rebound that has already taken place.

Conclusion

This paper has attempted to peek into the future a bit farther ahead than would be possible using only anticipatory data or leading indicators of investment such as appropriations, orders, or building contracts. I have introduced a variety of models, some of which must be adjudged less than total successes. I have emphasized a range of uncertainty. On balance, however, I feel that the FMP equations are most reliable for projecting the outlook, with the accelerator projection providing the most plausible alternative to it. There is enough diversity in the projections to encourage the hope that new data will facilitate discrimination among the models.

All of the projections are predicated on the implementation of new depreciation rules, although, at the time this is written, these rules are not yet formally effective. Further delay or uncertainty about the legal effect of the new rules could considerably dampen the outlook. In any case, neither these regulations nor reinstatement of the investment tax credit, which has been suggested, could be expected to have large immediate effects, though both apparently would have substantial long-run impacts, unless the accelerator is accepted as the best representation of investment behavior.

The year 1971 will be another year of stagnation for business fixed investment. Nonetheless, a rebound in 1972 and 1973 is projected by most models, and in the FMP and securities value models, the magnitude and speed of the rise could be said to characterize at least a "boomlet." Although none of the models shows investment as a dynamic sector leading the prospective recovery, it is not likely to drag far behind the rest of the economy. According to the more optimistic projections—which, I feel, are also the ones most apt to be realized—if real output grows significantly as a result of strength in other sectors, substantial gains in real investment are likely to follow.

APPENDIX A

Dynamic Investment Responses in Three Models

To trace the dynamic response through the accelerator, standard neoclassical, and putty-clay models, consider an industry producing a single homogeneous product, say, shoes. Suppose that this industry is monopolized by a single company, the Achilles Footwear Company,[1] that shoes are an absolute necessity, and that demand is 50 million pairs per year, regardless of price. Nevertheless, Achilles sells its shoes at marginal cost, because it fears entry by competitors.

Fixed Proportions—Accelerator Model

Suppose that in order to produce 5,000 pairs of shoes per year, the single available technology requires one machine, which may be rented from the Ajax Shoe Machinery Company for $10,000 per year, and five man-years of

1. The industry might just as well be competitive, but then there is a question of how firm size is determined.

labor, which may be hired at a wage of $8,000 per man-year. Each pair of shoes also requires 10 cents' worth of leather. Thus, shoes sell for $10.10 per pair.

Now, suppose that the machines are built to last forever, but that nevertheless 10 percent of them break down permanently each year (sabotaged by a disgruntled worker, or neglected by a careless maintenance man, for example) and that these breakdowns are equally likely regardless of the age of the machine (a nonessential but simplifying assumption). Given 10,000 machines—each costing Ajax $50,000—of which 1,000 break down each year, gross investment per year for the shoe machinery industry is $50 million.

What will be the response if, in a given year, demand increases to 60 million pairs, requiring 2,000 more machines? If the firms that supply Ajax with equipment manage to triple their output, gross investment for the year in question will rise to 3,000 machines, or $150 million. In each subsequent year, the usual 10 percent of all machines break down, and thus gross investment settles down to a new level of 1,200 machines, or $60 million per year. This is the familiar acceleration principle in action.

Ex Ante Variable Proportions—Putty-Clay Model

Suppose that instead of a single technology, there are a variety of ways to make shoes; here are data per machine for three methods, all of which produce 5,000 pairs per year:

Cost per new machine	*Rental*	*Workers*
$40,000	$ 8,000	5.275
50,000	10,000	5.000
60,000	12,000	4.775

With either the $40,000 or $60,000 machine, and one-man-year wages of $8,000, the cost of shoes is $10.14. Thus, the $50,000 machine is used at this wage. If wages rise to $10,000 per year, the cost of shoes produced on the $50,000 machine rises to $12.10 per pair, while the cost of those produced on the $60,000 machine rises only to $12.05. To avoid junking all of its old machines, Ajax lowers the rental on its $50,000 machines to $9,750, and writes off its losses, but it orders only $60,000 machines to replace those that break down. With continuing breakdowns of 1,000 machines per year, gross investment in the industry rises to, and stays at, $60 million per year.

If the wage did not change, but demand increased in the way assumed earlier, the investment response in this model would be exactly the same as that in the accelerator model. The difference lies only in the response to a change in relative prices—in this case the wage of man-years relative to the rental on machines. The response to a change in the interest rate (which is a factor underlying the rental price charged by Ajax and which I have implicitly assumed is 10 percent) would follow the same dynamic pattern. Also, the response would be the same if Achilles owned the machines instead of renting them.

This type of model is known popularly as the "putty-clay" model, because factor proportions are variable—like putty—before machines are built, purchased, and bolted down, but are fixed—like clay—once they are in place.

Freely Variable Factor Proportions—Standard Neoclassical Model

Now suppose that the $50,000 machines can, at a cost of $10,000, be made identical to the $60,000 machines, even after they are bolted down. Then, in the year of the wage change, instead of lowering the rent on old machines, Ajax would simply order 10,000 adaption kits. This would count as gross investment, and thus the investment aggregate would rise to $150 million for one year, then settle back down to $60 million per year. The effects of a change in demand are the same as in the accelerator model, and the investment response in this model is thus identical for changes in output and changes in relative prices. The standard neoclassical model essentially assumes that something like this can occur, although the example is oversimplified.

To sum up the exercise: In all three models the response to a change in output is the same. The reaction to a change in wages (or, in more general models, to interest rates, tax credits, and other variables) is quite different. In the accelerator model there is no response. In the standard neoclassical model, the reaction is identical to the response to an equivalent change in output. In the putty-clay model, however, the response to relative prices is much different. In particular, it should be noted that the level of gross investment in the transition to the more expensive machines never overshoots its new long-run level.

APPENDIX B

Statistical Notes

THE CAPITAL STOCKS included in each of the equations were derived as follows: First, benchmarks for the net stocks of equipment and structures at the end of 1946 and 1965 were taken from the U.S. Office of Business Economics, OBE Capital Goods Study, in the *Survey of Current Business*, Volume 49 (February 1969), pages 23 and 26. These were 118.7 and 227.8 (billions of 1958 dollars) for structures and 75.8 and 204.0 for equipment. Then the systems of equations given by

$$K_t = 0.25I_t + (1 - d')K_{t-1},$$

where

K_t = net capital stock at the end of the period t
I_t = gross investment in period t, and
d' = quarterly depreciation rate,

were solved for the values of d' that built the stocks up from the 1946 levels to the 1965 levels, using quarterly time series on investment in structures and equipment. The solved values of d' were approximately 0.0152 and 0.0386. Yearly depreciation rates d were derived from the values of d' using the formula $d = 1 - (1 - d')^4$. These were 0.0593 and 0.1457.

In specifying the *Hall-Jorgenson standard neoclassical model*, I have adopted their specifications wherever possible. The values of d are mine, rather than theirs. I have not included Robert A. Gordon's data on government-owned capital used in private production, nor have I adopted Gordon's price deflator for nonresidential construction, because the numbers were not available on a quarterly basis. Following Hall and Jorgenson, I have (1) used $0.20(1 - w)$ as the after-tax discount rate; (2) represented depreciation patterns after 1954 by the sum-of-the-years-digits formula; and (3) used 0.0587 (a weighted average of their rates for manufacturing and nonmanufacturing) for the effective rate of the investment tax credit.

For the FMP model the discount rate is

$$[2(RCBI - PX) + 1RDPI](1 - 0.2w)$$

for equipment and $2RDPI(1 - 0.2w)$ for structures. *RCBI* is Moody's industrial corporate bond yield. *PX* is the expected rate of price change derived in Ando, Modigliani, Rasche, and Turnovsky; it is a geometrically declining thirteen-quarter lag on past changes of the deflator for private output, with nonlinear threshold effects. *RDPI* is Moody's industrial dividend-price ratio. The discounted value of the depreciation deduction, z, is computed as $0.524zsyd + 0.476zsl$, for equipment, after 1954, and $0.534zsyd + 0.466zsl$, for structures; *zsyd* is the present value for sum-of-the-years-digits depreciation and *zsl* is the present value for straight-line depreciation. I have used 0.045 for the effective rate of the tax credit on equipment.

Rough estimates of the *market value of all nonfinancial corporations* were derived from a series, supplied by James Tobin, in which net nonfinancial interest payments were divided by the interest rate on new corporate issues and nonfinancial dividend payments were divided by Moody's composite dividend-price ratio.

APPENDIX C

Assumptions and Data Sources

THE FOLLOWING ARE THE BASIC assumptions for the projections.

1. *Real business gross product* is assumed to rise $14 billion in 1971:1, under the influence of recovery from the automobile strike, and to rise about 0.9 percent per quarter for the next four quarters, except for the effects of a sixty-day steel strike in 1971:3. For the rest of 1972, the rise is assumed to average 1.6 percent per quarter, with a slight slowing of real growth in early 1973. This projection is consistent with a 1971 gross national product of $1,046 billion in current dollars, or $743 billion in constant (1958) dollars.

2. The rate of increase of the *price deflator for business gross product* is

assumed to decline gradually from 1.1 percent per quarter in early 1971 to 0.9 percent per quarter in early 1973.

3. The *cash flow of domestic corporations* (profits after taxes plus capital consumption allowances) is assumed to grow from $94.2 billion in 1970:3 and a slightly lower level in 1970:4 to $128.2 billion in 1973:2, consistent with the recovery of output and the increase in depreciation deductions under the new government policy.[1]

4. Consistent with the profits and depreciation assumptions, the dividends of nonfinancial corporations are assumed to rise from $21.8 billion in 1970:3 and a slightly lower level in 1970:4 to $27.4 billion in 1973:2.

5. The *market value of the equities of nonfinancial corporations* is assumed to rise 22.6 percent between 1971:1 and 1973:2. This is consistent with a rise of the Standard and Poor Corporation's combined index of 500 stocks from a close of 100.31 on March 31, 1971, to 116.0 in 1973:2 (1941–43 = 10).

6. Assumptions 4 and 5 imply a path for Moody's *composite dividend yield,* determined by dividing dividends by value of equities of nonfinancial corporations; the yield declines to 0.0326 in 1972:1 and then rises gradually to 0.0355 in 1973:2. The Moody's industrial dividend yield is assumed to move approximately 35 basis points below the composite yield.

7. The *net interest payments of nonfinancial corporations* are assumed to rise from $14.5 billion in 1970:4 to $17.4 billion in 1973:2.

8. The *yield on new issues of corporate bonds* is assumed to fall from 0.0875 in 1970:4 to 0.0765 in 1971:1 and to remain stable at that level. *Moody's composite corporate bond yield* is assumed to decline from 0.0854 in 1970:4 to 0.0787 in 1971:1 and then to move gradually towards 0.0765. *Moody's industrial bond yield* is assumed to decline from 0.0822 in 1970:4 towards a stable level of 0.0737, remaining 3.75 percent below the composite yield.

9. Assumptions 7 and 8 imply a path for the *market value of the bonds of nonfinancial corporations,* evaluated by dividing net interest payments by the yield on corporate new issues, which entails a rise from $166 billion in 1970:4 to $192 billion in 1971:1 and then to $227 billion in 1973:2.

10. The *price deflator for producers' durable equipment* is assumed to rise, but at a gradually decreasing rate, from 1.223 in 1970:4 to approximately 1.313 in 1973:2, varying about this path in any given simulation in

1. All quarterly flows mentioned are at annual rates.

accordance with the degree of inflation induced by the projected demand for capital goods.

11. The *price deflator for nonresidential construction* is assumed to rise at a gradually decreasing rate from 1.591 in 1970:4 to 1.865 in 1973:2, varying about this path in any given simulation in accordance with the degree of inflation induced by the projected demand for capital goods.

Assumptions 3, 4, and 7, concerning corporate profits, depreciation, dividends, and interest payments have been checked for consistency with the output assumptions using equations adapted from the forecasting model of Chase Econometric Associates, Inc., made available with the permission of Michael K. Evans. Assumptions 10 and 11, concerning the price deflators for capital goods, are derived from the two most recent basic solutions of that model, and the formulas used for varying these prices in individual simulations are derived from the equations from that model. The sources for this basic solution are two unpublished releases of Chase Econometric Associates, Inc., "Forecasts of February 22, 1971" and "Forecasts of March 23, 1971." The source for the model equations is an unpublished notebook, "Macro-Economic Model," provided by Dr. Evans.

Assumptions for "Government Forecast" Projections

These simulations assume paths of business gross product, corporate cash flows, and price deflators for business gross product, equipment, and nonresidential construction that are consistent with achievement of the government "target" of a $1,065 billion (current dollars) gross national product in 1971. Exogenous upward adjustments sufficient to attain the target are made in equations for automobile purchases, inventory investment, and residential construction. The source is the release, "Forecasts of February 22, 1971," mentioned above.

Sources of Data

Historical data for the variables listed under 1, 2, 3, 4, 7, 10, and 11 are found in U.S. Department of Commerce, *The National Income and Product Accounts of the United States, 1929–1965*; *Statistical Tables* (1966); *Survey of Current Business*, Volumes 48 (July 1968), 50 (July 1970), and 51 (February 1971). Real business gross product is found in Table 1.8, line 3, of *National Income and Product Accounts* and in the corresponding tables in *Survey of Current Business*. The implicit price deflator for business gross product is in Table 8.4, line 3, in *National Income and Product Accounts*. Cash flow of domestic financial corporations is in Table 1.14, line 16. Net interest payments and dividends of nonfinancial corporations are in Table 1.14, lines 24 and 29. Price deflators for equipment and nonresidential construction are in Table 8.1, lines 9 and 10.

Historical data for Moody's dividend yields and Moody's bond yields are found in various issues of *Survey of Current Business*, generally on page S-20, and in the supplement, *1969 Business Statistics*, 17th Biennial Edition (1970). Historical data for the yield on new issues of corporate bonds are from various issues of *Business Conditions Digest*, listed as Series 116. The market values of bonds and equities of nonfinancial corporations were calculated by the author. Historical data for Standard and Poor's combined index of 500 stocks are found on page S-21 of *Survey of Current Business* and in *1969 Business Statistics*.

Comments and Discussion

Barry Bosworth: This comparative study of investment models is to be commended because it uses a common set of data and common time period, and because, unlike several previous studies, it attempts to use a common statistical technique. It is striking that, over the period of estimation, the alternative formulations of investment behavior all fit relatively well. Their fits are barely distinguishable from one another, in part because of the use of the autocorrelation adjustments, in part because of the great power of least-squares regression to make things fit.

But, when we turn to the predictions, a wide range of differences emerges. It is somewhat disappointing that, after a decade of intensive research, we can achieve so little agreement in predicting investment. In view of this situation, I decided to look again at the basic theories of investment and some of the data problems involved.

The simplest formulation of investment behavior is the accelerator model. It postulates that the capital-output ratio, though it may change over time, does not change in response to other economic variables, such as relative prices. The neoclassical model attempts to extend the accelerator model by allowing the desired capital stock to be affected by relative prices. In the neoclassical theoretical view, capital is treated essentially as a variable input, and thus no differently from labor. Capital can be "rented," as it were, for the short run. Thus, theory ignores the irreversible long-term character of investment—a matter that is greatly stressed in the theory of the firm. The neoclassical model takes a myopic view of the investment decision, comparing the current productivity and the rental cost of capital; it thus finesses the standard practice of summing discounted future income flows to see whether a project is profitable over its lifetime.

The irreversibility is brought in, however, when the model is modified to allow for imperfections in the resale market for capital. But that leaves us with two different rules: The discounted present value of future income flow indicates whether a given investment would be ultimately profitable, while the myopic rule indicates whether now is the best time to make that investment. That split of the decision process is not a satisfactory solution and its weakness may be empirically important, because the two rules may depart from each other over the business cycle. Long-term expectations should influence investment behavior and they do not necessarily conform to the business situation of the moment or to mechanical moving averages of the past. For example, after nine years of continuous economic expansion, businessmen may have concluded in 1969 that government policy would generally keep the economy close to potential output.

The real rate of interest becomes an odd concept in this formulation. It is the net combination of a nominal discount rate used for the investment decision and a rate of expected capital gains (or losses) on investment goods. Only if the resale market is perfect, however, will the expectation of greater capital gains just offset the influence of an equal rise in the interest or discount rate. The two influences may not be symmetric.

I am also bothered by the fact that the elasticity of substitution is really the only interesting empirical parameter in the neoclassical model. The focus on that elasticity, in effect, makes three bold assumptions: that firms have correct a priori knowledge of all production opportunities, that alternative methods of production are available, and that firms maximize profits. The neoclassical model does offer a useful analytical technique for dealing with a variety of changes in taxes and interest rates. But some of the empirical applications leave me uncomfortable—for example, the exclusion of property taxes.

There is a third approach, which is not well represented by any of the empirical models Bischoff reviews. That model, which I shall call the flow-of-funds model, extends the neoclassical approach by making the discount rate a function of the internal financial structure of the firm. The crucial aspect of this model is the balancing of financial stocks and flows. Such a model has the major advantage of specifying an optimal rate of adjustment for capital stocks and integrating the theories of production and valuation. John Lintner has done some empirical work along these lines, showing the influence of debt positions as well as prices and interest rates on investment.

The Federal Reserve–MIT–Penn (FMP) model lies between the neoclassical and flow-of-funds models. The discount rate is a weighted average of dividend and bond yields, and hence matches the ex post cost of capital.

But it may not be a good measure of the ex ante cost of capital as viewed by the firm; for example, the firm would view the cost of equity capital as including expected capital gains on stocks. The central aspect of the FMP model, as Bischoff emphasizes, is the differential lag in the responses to output and prices. The putty-clay model would account for such a differential lag, as Bischoff points out. But there are many other reasons why firms might react more promptly to rises in output than to changes in relative prices.

Empirical work on investment should recognize that investment arises from many different motives, and that these apply differently in different industries. Regulated industries like utilities do not behave the way manufacturing does. Commercial construction presents still a different case; the decision to produce building space is basically an inventory decision influenced by vacancy rates. Hence, it would be useful to disaggregate the investment data and develop investment functions by sector.

These differences between sectors seem especially important in the current situation. I would expect that, in the near future, investment by public utilities will continue to be strong; that commercial construction will begin to flatten out, declining less rapidly than in recent quarters; and that manufacturing investment will continue rather weak until the rest of the economy resumes a substantial upturn.

Robert Hall: The paper offers a useful comparison of the various models, but the comparison is not as neat and clean as I would have hoped. In the first place, the statistical adjustment for autocorrelation obscures the differences. If the standard errors of the equations are taken *without* the autocorrelation adjustment, FMP stands out as far superior to its closest competitor, the cash flow model.

Even more important, Bischoff's equations are substantial generalizations of the underlying models. For example, his version of the standard neoclassical model departs in three ways from what I would regard as the standard neoclassical model. First, the equation has a constant term that theoretically does not belong there. Second, the neoclassical equation used by Jorgenson does not sum the coefficients on a lagged, relative price variable, but sums the coefficients on a change in the relative price variable, and constrains the sum of the coefficients to be zero. Third, Bischoff treats capital stock as an independent variable with a fitted coefficient, while the neoclassical logic requires that the coefficient be equal to the replacement rate, which is supposedly known in advance. These departures from my notion of the neoclassical model are generalizations that should improve the fit of the equation; in other words, they make the standard neoclassical (SNC) model look better during the sample period. But they may also explain why the investment projections by that model are so implausibly low relative to those of other models.

Something has to be holding the SNC forecasts down; the constant term is one thing that could reduce the accelerator response to changes in output, but that can't be the whole story. The flatness of the SNC projection remains, in part, a mystery to me.[1]

Finally, I want to urge caution in interpreting the calculated effects of changes in tax policy. Many things, such as interest rates and prices, are held constant in these calculations and some of them would not be likely to remain constant in fact. If price equals full cost, including the cost of capital, and if the "rental" price of capital changes while the price of output and interest rates do not, a compensating change in wages is implied. There is thus a hidden assumption that wages go up whenever the cost of capital goes down. In addition, holding constant the market interest rate (that is, interest before taxes) results in the interest rate after taxes falling by the full proportionate amount of any tax increase or rising by the full amount of a tax reduction. In fact, one would expect the interest rate on corporate debt to be sensitive to the corporate tax rate. Furthermore, there is an assumption that the *marginal* cost of borrowing is fully tax deductible and that is unrealistic; at most, the average cost is deductible, and even that is not the case when equity funds are raised. Last, the calculations assume zero shifting of the corporate tax, another extreme and unrealistic assumption.

General Discussion

Robert Eisner was concerned that the many critical assumptions in these models be made clear in examining the implications of tax changes, especially with respect to accelerated depreciation. It is not known how depre-

1. I have subsequently learned that the problem is that the constants in the accelerator and FMP equations are large and negative. Again, the logic of those models suggests that there should be no constants.

ciation affects either the relative price of capital or the concept of cash flow relevant to capital spending decisions. Investment functions are concerned with anticipations of the *future*, and the variables from the past and present that are measurable serve primarily as proxies for expectations. There is no particular reason to assume that a given increase in measured cash flow due to accelerated depreciation creates the same anticipated changes as one due to a rise in profits.

Alan Greenspan felt that the data on real investment in structures might have been biased downward, particularly in recent years, by the use of the official price deflators, which virtually rule out the possibility of productivity gains in construction. He noted that a more realistic price series is available, although only on an annual basis. Robert Eisner regretted that the elasticity of substitution had been assumed to have a value of 1 for equipment and of 0.5 for construction, rather than being freely estimated in this study. He felt that the unity value for equipment was considerably too high. Bischoff emphasized that he had estimated the elasticity of substitution in a number of other studies. The estimates of elasticity for equipment tended to come out somewhat above 1 when freely estimated, but he had scaled it down for this study on a priori grounds.