A COMPARISON OF ALTERNATIVE ECONOMETRIC MODELS OF QUARTERLY INVESTMENT BEHAVIOR

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In this paper four alternative quarterly econometric models of investment behavior are fitted to a common set of data for individual manufacturing industries in the United States. Goodness of fit and absence of autocorrelation of errors are used as a basis for comparison of the performance of the alternative models. The econometric models are compared with each other and with alternative explanations of data on investment based on surveys of anticipated investment and on mechanical forecasting schemes. The four econometric models included in our study are those of Anderson [2], Eisner [15], Jorgenson and Stephenson [38], and Meyer and Glauber [46]. On the basis of our comparison, the ranking of the alternative models is as follows: (1) Jorgenson-Stephenson, (2) Eisner, (3) Meyer-Glauber, (4) Anderson. Anticipatory data give a better fit to data on investment expenditures than that provided by any of the econometric models. Mechanical forecasting schemes provide a fit that is superior to the Anderson and Meyer-Glauber models. These schemes are slightly inferior to the Eisner model and clearly inferior to the Jorgenson-Stephenson model. The alternative econometric models included in our comparison differ in specification of the time structure of the investment process and in the role ascribed to specific determinants of investment behavior. Both aspects of an econometric model affect its performance so that it is difficult to discriminate among alternative determinants of investment behavior on the basis of our results.

I. INTRODUCTION

Much effort has been devoted to the analysis of quarterly data on investment expenditures from the Investment Survey of the Office of Business Economics (OBE) and the Securities and Exchange Commission (SEC).\(^1\) There are currently available no less than six sets of investment functions fitted to post-war OBE-SEC Survey data for two-digit industry groups within manufacturing.\(^2\) There are many additional investment functions fitted to post-war data for aggregates of these

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\(^1\) The OBE-SEC Survey is currently published in the March, June, September, and December issues of the Survey of Current Business [57].

\(^2\) Sets of investment functions fitted to quarterly data have been published by Anderson [2], Eisner [11, 12, 13, 14, 15, 16, 18], Jorgenson and Stephenson [37, 38, 39] and Meyer and Glauber [46]. Sets of investment functions fitted to annual data have been published by Bourneuf [3] and Hickman [29]. A preliminary version of this study was presented at the Winter Meetings of the Econometric Society in December, 1964. The empirical part of the study was subsequently revised and expanded. Since the empirical research was completed, two additional sets of investment functions fitted to quarterly data have been published by Resek [49] and by Evans [20]. These studies appeared too late to be considered for inclusion in the comparison of alternative econometric models described below.
industry groups such as total manufacturing. Each set of investment functions corresponds to an econometric model of investment behavior. The alternative models have widely different implications for the determinants of investment behavior and for the time structure of the investment process. The resulting investment functions differ markedly in the weights that are associated with various explanatory variables and in the relative degree of explanation of the post-war data on investment expenditures.

Any attempt to appraise alternative econometric models of investment behavior on the basis of accepted standards of validity of specification, such as goodness of fit and absence of autocorrelation in the underlying errors, reveals, surprisingly, that the information already available is insufficient to provide a basis for comparison. The alternative investment functions have been fitted to different sub-periods within the post-war period. Some functions have been fitted to deflated data, others to undeflated data, some to seasonally adjusted data, others to unadjusted data, and so on. None of the investment functions can be compared directly with the others for the same data on investment expenditures.

A comparison of alternative econometric models of investment behavior is essential to provide an appropriate basis for further empirical research. Many theoretical points of view about investment behavior are already represented in the econometric literature. A number of statistical treatments of the time structure of the investment process have been proposed. Only systematic comparisons among the available alternatives can lead to accumulation of knowledge on the basis of the performance in empirical research. In the absence of such comparisons, econometric research on investment will continue to be characterized by a proliferation of still further alternatives, with no means of discrimination between explanations that are inferior to those already available and those that represent a genuine advance in the explanation of investment behavior.

The first purpose of this paper is to compare investment functions for the industries within manufacturing for which data are published in the OBE-SEC Survey. For each of a number of econometric models studied in the current literature, investment functions will be fitted to a common set of data on investment expenditures. The validity of the alternative specifications will then be compared on the basis of goodness of fit and absence of autocorrelation of the underlying errors. On the basis of this comparison conclusions can be drawn about the determinants of investment behavior and the time structure of the investment process.

The second purpose of this paper is to compare investment functions based on econometric models with explanations of the investment data based on purely mechanical schemes and on the use of anticipatory data. A minimum standard for the performance of an econometric model for economic time series is that it should provide a better explanation of time series behavior than a purely mechanical forecasting scheme. The mechanical scheme implicit in conventional measures

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3 A very detailed review of the empirical literature through 1960 has been given by Eisner and Strotz [19]. A more concise review of empirical studies through 1962 is given by Kuh [41] and by Smyth [51]. Empirical studies published since 1962 in addition to those listed in footnote 2 above include those of Anderson [1], Dhrymes and Kurz [6], Eckstein [10], Greenberg [21, 22], Griliches and Wallace [24], Hall and Jorgenson [27], Hart [28], Kuh [42], Lintner [43], Okun [48], Sachs and Hart [50], and Stigler [53].
COMPARISON OF INVESTMENT MODELS

of goodness of fit, namely, that the observations are drawn independently from a fixed distribution, is obviously uninteresting. Most economic time series are serially dependent and in some cases appear to be nonstationary. A statistical model that incorporates one or both of these features provides a more interesting alternative to an econometric model.

For investment expenditures as reported in the OBE-SEC Survey, an alternative explanation to that provided by econometric models may be based on anticipated investment expenditures. While econometric models are superior to unmodified anticipatory data in explaining actual expenditures, a more sophisticated comparison may be based on the best explanation of investment expenditures from past values of anticipated investment. A comparison of this type is not intended to provide a standard for performance of econometric models but rather an evaluation of the usefulness of anticipatory data when properly modified by incorporation into a statistical model.

In the following section of the paper we review the alternative econometric models of investment behavior available in the literature. From the wide range of available models we select four that may be taken to represent the main theories of investment currently under study. Our criteria for selection assure that each model has passed the stringent tests of providing both an explanation for investment behavior at the level of individual industries and a representation of the time structure of investment behavior for quarterly observations. In Section 3 we discuss the mechanical scheme to be used as a standard for evaluating the performance of econometric models, an autoregression of investment on its own past values. This scheme incorporates as special cases a number of the “naive” models used for a similar purpose in earlier work on the evaluation of econometric models. For quarterly data it provides a very stringent standard for performance of an econometric model, as our empirical results reveal.

In Section 4 of the paper we discuss sets of investment functions fitted to quarterly data for the period from the first quarter of 1949 to the fourth quarter of 1964 for each of the econometric models included in the study and for regressions of investment on its own past values and on anticipatory data. In Section 5 we compare the alternative econometric models with regard to their ability to explain data at the level of individual industry groups; we also compare the explanatory power of econometric models with that of autoregressive schemes and anticipatory data. In Section 6 we summarize the empirical results and draw conclusions concerning the determinants of investment behavior and the time structure of the investment process. The following paper is devoted to tests of the econometric models for structural change and to an evaluation of the predictive performance of the alternative econometric models.

2. REVIEW OF THE LITERATURE

At the time this study was undertaken six sets of investment functions had been fitted to post-war quarterly data from the OBE-SEC Survey for the two-digit industries of manufacturing. A much larger number of investment functions had

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4 See, for example, the comparison by Jorgenson [31, Table 2.5, pp. 70–1].
been fitted to OBE-SEC data for total manufacturing. Since our primary objective is to compare the validity of specification of alternative econometric models of investment behavior, our comparison includes models representative of the main theoretical viewpoints about investment behavior current in the literature. At the same time it is clearly infeasible to study all of the alternative models that have been proposed. Even within a given study of investment behavior a variety of distinct alternatives may be considered and all but one or two rejected. An exhaustive comparison would require retracing the steps of every investigator through each of the intermediate stages of his research to make sure that nothing worthwhile had been eliminated in the course of the research process. Similarly, among alternative econometric models of investment there are a number of recognizable points of view that have been employed as a basis for econometric work, some by a single investigator and others by several. Minor variants of a given point of view should be compared in detail only after the validity of the general approach has been established.

In view of the need for selection of a small group of econometric models from a vast range of possibilities, we have adopted the following principles of selection. First, to be included in the study a given econometric model must be tested at the level of individual industry groups and not for total manufacturing alone. As Anderson has emphasized [2, p. 108], empirical support at the level of industry groups provides protection against the effects of "data mining," that is, goodness of fit resulting solely from the selection of the best fitting hypothesis among a very broad range of alternative specifications at the aggregate level. If the specification of an econometric model of investment behavior is supported by evidence at the level of the individual industry group we have much better grounds for acceptance than if the specification is supported only by goodness of fit at the aggregate level. This criterion rules out all but six econometric models of investment behavior. A second criterion for inclusion in this study is that an econometric model must be tested for quarterly data on investment expenditures rather than for annual data alone. Since the work of Chenery [5] and Koyck [40], the great importance of a correct specification of the time structure of the investment process has been recognized in almost all empirical work on investment behavior. The validity of the explanation of quarterly variations in investment expenditures is a far better criterion for the validity of the specification of the time structure than explanation of annual variations in investment. Accordingly, we limit consideration to econometric models that have been tested against quarterly data. This criterion reduces the number of econometric models to be included in our study to four; we review each of these four specifications of the determinants of investment behavior and time structure of the investment process.

A. Anderson

The first econometric model of investment behavior to be considered has been proposed by W. H. Locke Anderson in his monograph, Corporate Finance and Fixed Investment [2]. The determinants of investment expenditures in Anderson's
model include three familiar elements—pressure on capacity, profits, and interest rates—and three novel ones—stocks of government securities held at the beginning of the period, accrued tax liability at the end of the period, and long-term debt capacity. Pressure on capacity is measured by the difference between actual sales and previous maximum sales, taken as a measure of productive capacity. Long-term debt capacity is defined as the difference between eighteen per cent of total assets and outstanding long-term debt at the beginning of the period. Debt capacity represents the availability of unused borrowing ability while stocks of governments and tax liability determine available liquidity and the need for liquid assets. Anderson emphasizes the neoclassical origin of the underlying model, which may be traced to James S. Duesenberry’s *Business Cycles and Economic Growth* [7].

The model is characterized as:

...a restatement of the neoclassical position that investment is determined by the intersection of the marginal efficiency schedule with the marginal cost of funds schedule. The marginal efficiency schedule, Duesenberry argues, shifts about primarily in response to changes in the rate of utilization of existing capacity. The marginal cost of funds schedule shifts about in response to changes in the degree of financial risk as well as to changes in the market cost of funds [2, p. 37].

Anderson divides the time structure of the investment process into three separate components. First, there may be a lag between changes in the determinants of investment behavior and changes in the anticipated values of these variables that determine behavior. Alternatively, expectations may be determined by a trend plus some constant proportion of the deviation of the actual variable from trend. (See [2, pp. 64–65].) This is the expectations mechanism used in the form of the model employed for two-digit industry groups. The second part of the time structure of the investment process is a lag from a change in the expected values of determinants of investment behavior to the actual decision to invest. Anderson identifies the final decision with the appropriation of funds [2, pp. 65–66]. He treats the decision lag as a fixed parameter to be estimated from the data. Finally, there is a lag from the investment decision to actual expenditures, that is, from appropriations to actual investment. This lag is distributed over time. Anderson determines the distribution empirically from data on appropriations and investment. The lag distribution assigns equal weights to appropriations lagged one through four periods so that the average lag is two and a half quarters [2, pp. 66–70].

As a consequence of this empirical finding, Anderson represents the underlying determinants of investment as four quarter moving averages of quarterly data. For two digit industries: “In all cases but three, the best decision lag seemed to be three quarters, the lag which yielded the best results for aggregate manufacturing” [2, p. 113]. For the time structure of the investment process as a whole a three quarter decision lag implies a lag of five and a half quarters plus the lag from actual to expected values of the determinants of investment.

To determine the lag structure from changes in the actual values of the determinants of investment to investment expenditures, we may employ one of the specifications of the lag in expectations considered by Anderson, namely, that this lag is geometric. The average lag in the investment process as a whole for total
manufacturing is estimated by this means at 6.5 quarters; since the average lag other than that in expectations is estimated at five and a half quarters, the expectations lag is estimated at one quarter. The shape of the lag distribution is also of interest. Changes in the determinants of investment behavior have no impact on actual expenditures until four quarters have elapsed. In the fourth quarter subsequent to the change, .120 of the long-run effect on investment is realized; this proportion rises steadily until the seventh quarter after the change, reaching a peak of .232 of the long-run effect; from that point forward the effect declines geometrically at a rate .520 per quarter. It is impossible to analyze the lag distribution in the same way for the alternative specifications of the expectations hypothesis considered by Anderson.\(^5\) As a result no corresponding analysis for the time structure of investment behavior at the two-digit industry level can be given.

We now present a more formal version of Anderson’s model, including his specification of the determinants of investment and of the time structure of the investment process. First, let investment in current prices be \(q_t I_t\), where \(q_t\) is the price of investment goods and \(I_t\) the quantity of investment expenditures. The model takes the form

\[
q_t I_t = \beta_0 + \beta_1 t + \beta_2 (S - S_{\text{max}})_{t-3} + \beta_3 RED_{t-3} + \beta_4 G_{t-3} \\
+ \beta_5 T_{a,t-3} + \beta_6 K_{DL,t-3} + \beta_7 i_{t-3} + \beta_8 Q_1 \\
+ \beta_9 Q_2 + \beta_{10} Q_3 + \epsilon_t.
\]

In this model a bar over a variable (\(^-\)) indicates a moving average for four quarters beginning with the quarter indicated (e.g., \(t - 3\)) and extending backward. The variable \(t\) is a time trend, \(S - S_{\text{max}}\) corresponds to pressure on capacity, where \(S\) is sales and \(S_{\text{max}}\) is its previous maximum value, \(RED\) is gross retained profits, the sum of retained earnings and depreciation expense, and \(i^*\) the Treasury bill yield. The time trend is introduced to account for difference between actual and anticipated values of the determinants of investment expenditures. The other three variables represent the effects of capacity utilization, profit, and the interest rate. The variable \(G\) is the stock of government securities held at the beginning of the period, \(T_a\) is accrued tax liability at the end of the period, and \(K_{DL}\) is long-term debt capacity. These variables represent the effects of the need for liquidity and the riskiness of borrowing. The variables \(Q_1, Q_2\) and \(Q_3\) are seasonal dummy variables, equal to one in the corresponding quarter and zero otherwise.

Anderson has fitted the econometric model (1) to quarterly data for thirteen of the fifteen industry groups for which data are reported in the OBE-SEC Survey. He excludes other durables and other nondurables, which are rather heterogeneous groupings of two-digit industries within manufacturing. Except for the time trend, the seasonal dummy variables, and the Treasury bill rate [55], all of the independent

\(^5\) The geometric specification is employed by Anderson only for total manufacturing; all results we have described are for the fitted investment function given by Anderson [2, p. 75, Table 5–3, line (5)]. The alternative expectations mechanisms considered by Anderson are given on pp. 68–69. For the trend-deviation model, investment cannot be expressed as a weighted average of past values of its determinants.
variables are derived from the Quarterly Financial Report [61] published by the Securities and Exchange Commission (SEC) and the Federal Trade Commission (FTC). None of the variables are deflated or seasonally adjusted. The sample period extends from the first quarter of 1949 to the fourth quarter of 1958, a total of forty quarters.

B. Eisner

The second model to be considered has been proposed by Robert Eisner in a series of articles. The determinants of investment include changes in sales and changes in profits together with the level of capital stock. The level of capital stock is taken to determine investment for replacement purposes. The underlying model is a version of the flexible accelerator originated by Chenery and Koyck. (See [15, p. 198].) Investment net of replacement is equal to a weighted average of past changes in output. Changes in profits are introduced as a possible representation of changes in "the expected profitability of investment [18, p. 97]. The relationship of this model to the theory of the firm is characterized by Eisner as follows:

\[
\text{\ldots The acceleration principle whose manifestations we shall note and investigate is not the simple first or second order difference equation frequently presented, presumably in the interest of pedagogical clarity. Rather, we have in mind a world of risk and uncertainty in which business firms strive to maximize the mathematical expectation of some monotonic increasing function of expected future profit, subject to a production function with decreasing marginal returns to each factor and positive cross partial derivatives. This means, in particular, that for a firm initially in equilibrium it pays to increase the stock of capital for permanent or certainly expected increases in demand for output [12, p. 1].}
\]

Eisner treats the time structure of investment behavior by means of a modification of Koyck's distributed lag function. The weights in this function are determined arbitrarily for the first lagged values of profits and sales and then decline geometrically [15, p. 198]. The complete model, as we have outlined it, has been applied to data from the OBE-SEC Survey for total durable and total nondurable industries within manufacturing for the realization of investment expenditures, given anticipations, for the period from the third quarter of 1948 to the fourth quarter of 1960, a total of fifty quarterly observations. Similar but not identical models have been applied to annual data on investment expenditures for cross sections of firms from the McGraw-Hill Survey (see [12, p. 11]) for individual industry groups within manufacturing, specifically, food and tobacco, chemicals, petroleum, machinery, and rubber, metals, and autos taken together. For this purpose the time structure of the investment process is characterized by a finite distributed lag function.

At the time of our study, Eisner's model had not been tested at the level of individual industries for quarterly data from the OBE-SEC Survey; his tests of

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6 Calculation of the variable $S - S_{max}$ follows the method described by Anderson [2, p. 70]. Further details are given in the Statistical Appendix to a more extensive version of this paper available from the authors.

7 This model is discussed by Eisner in a number of articles [11, 12, 13, 14, 15, 16, 18]; results for data from the OBE-SEC Survey are given by Eisner in two of these articles [15, 18].
the model for annual data on investment by individual firms, grouped by industry, provides sufficient support for the model at the level of individual industry groups to merit its inclusion in our study. The problem that remains is to select a representation of the time structure of the investment process from among those considered by Eisner. As our primary guide in this selection process we employed the form of the lag distribution implicit in Eisner's analysis of investment realizations for quarterly data from the OBE-SEC Survey [15, 18]. Eisner's analysis of investment realizations provides support for the validity of his specification of the time structure by testing this specification for quarterly data from the OBE-SEC Survey. This is the only specification among those employed by Eisner that had been tested at the quarterly level at the time of our study.\(^8\)

A formalization of the version of Eisner's model used in our study, including his specification of the determinants of investment expenditures and of the time structure of the investment process for quarterly time series, is the following:

\[
I_t = \beta_0 + \beta_1 \Delta S_{t-1} + \beta_2 \Delta S_{t-2} + \beta_3 \Delta P_{t-1} + \beta_4 \Delta P_{t-2} + \beta_5 I_{t-1} + \beta_6 K_t + \epsilon_t.
\]

In this model \(\Delta S\) is change in sales, \(\Delta P\) is change in profits, \(K\) is capital stock at the beginning of the period. The lagged value of investment expenditures is introduced in order to represent the effects of changes in sales and profits lagged more than two periods; the weights associated with these changes decline geometrically.

Capital stock is estimated from investment expenditures data from the OBE-SEC Survey with benchmarks from Statistics of Income [59]. Sales and profits changes are taken from the SEC-FTC Quarterly Financial Report [61]; sales are deflated by the wholesale price index for each industry group, computed from Bureau of Labor Statistics [58] data. Profits are deflated by the price index of investment goods, constructed as a weighted average of implicit deflators for producers' durables and for nonfarm, nonresidential construction from the U.S. national income and product accounts [56] with weights from the OBE Capital Goods Study [30]. All data are seasonally adjusted.

C. Jorgenson-Stephenson

The third model to be considered in our study has been proposed by Dale W. Jorgenson and James A. Stephenson in a series of articles.\(^9\) The determinants of investment expenditures in the Jorgenson-Stephenson model include the value of output in current prices and the price of capital services together with capital stock, which is taken to determine investment for replacement. The price of capital

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\(^8\) Of course, tests of the model for investment realizations provide support for Eisner's specification of models for investment and for anticipated investment simultaneously. The specification for the model of investment alone used in our study was suggested to us by Robert Eisner in a personal letter to M. I. Nadiri, dated July 23, 1964 [17]. We are grateful to Eisner for this assistance in interpreting the model for investment realizations used in his studies of data from the OBE-SEC Survey.

\(^9\) See Jorgenson and Stephenson [37, 38, 39]; see also, Jorgenson [31, 32].
services depends in turn on the price of investment goods, the cost of capital, and the tax structure for business income. Specifically, the price of capital services depends on the following features of the tax structure: the rate of income tax, the proportion of replacement in current prices that can be deducted from income for tax purposes, and the proportion of the cost of capital that can be deducted from business income. The theoretical basis for the model is the neoclassical theory of optimal accumulation of capital. In this theory,

... the criterion for optimal accumulation is to maximize the present value of the firm. We assume that the productive process may be characterized by a production function relating flows of output to flows of labor and capital services and that the firm supplies capital services to itself through the acquisition of investment goods. ... In view of the importance of direct taxation of business income in the United States manufacturing sector, which is largely corporate, we include a detailed description of the tax structure. Direct taxes are assessed on the basis of business income as defined for tax purposes. The definition of business income depends on the tax treatment of depreciation, the cost of capital, and capital gains and losses [38, p. 174].

Jorgenson and Stephenson characterize the time structure of the investment process by a rational distributed lag function of the general Pascal type. This distributed lag function includes the geometric, Pascal, and finite distributed lag functions as special cases. A detailed analysis of the lag structure for individual industry groups within manufacturing leads to the following conclusions:

... We find that investment expenditure lags behind its determinants by six to twelve quarters or from a year and a half to three years on the average. For each industry, investment expenditure is unaffected by change in its underlying determinants for at least two quarters. Beginning at moderate levels, investment expenditure rises rapidly to a peak that occurs between four and eight quarters after the changes in its underlying determinants. After the peak is attained the level of investment expenditure falls off gradually. The positive effect on investment expenditure of changes in its underlying determinants is limited to a period often as short as three quarters [39, p. 17].

A second conclusion is that the geometric distributed lag function does not provide a satisfactory representation of the lag structure underlying investment behavior for quarterly data [39, p. 23].

The Jorgenson-Stephenson model takes the form:

\[ I_t = \beta_0 + \beta_1 A \left( \frac{pQ}{c} \right)_{t-4} + \beta_2 A \left( \frac{pQ}{c} \right)_{t-5} + \beta_3 A \left( \frac{pQ}{c} \right)_{t-6} + \beta_4 A \left( \frac{pQ}{c} \right)_{t-7} + \beta_5 (I - \delta K_{t-1}) + \beta_6 (I - \delta K_{t-2}) + \beta_7 K_t + \varepsilon_t. \]

In this model \( pQ \) is gross value added in current prices; \( c \) is the price of capital services, defined as

\[ c = q \left[ \frac{1 - uw}{1 - u} \delta + \frac{1 - uw}{1 - u} r \right], \]

where \( q \) is the price of investment goods, \( \delta \) the rate of replacement, \( r \) the cost of capital, \( u \) the tax rate, and \( \nu \) the proportion of replacement deductible from income.

\[ 10 \text{ For further discussion, see Jorgenson [33, pp. 138–139].} \]
for tax purposes, and \( w \) the proportion of the cost of capital deductible from income. As before, \( K \) is capital stock at the beginning of the period. The values of lagged net investment, \( I - \delta K \), are introduced as part of the representation of the time structure of the investment process. Capital stock is estimated from investment expenditures data from the OBE-SEC Survey. The value of output is taken to be gross value added in each industry. The components of value added and the elements of the tax structure are taken from annual levels of profits, depreciation, and so on, from the U.S. national income and product accounts [56], distributed by quarterly data from the SEC-FTC Quarterly Financial Report [61]. The price of investment goods is a weighted average of investment deflators for plant and equipment from the U.S. national accounts [56]. The cost of capital is the ratio of return to capital net of replacement to the value of the firm as measured in the stock market.

Jorgenson and Stephenson have fitted the econometric model (3) to quarterly data for all fifteen industry groups of manufacturing for which data are available in the OBE-SEC Survey. The sample period for the Jorgenson-Stephenson study extends from the first quarter of 1949 to the last quarter of 1960, a total of forty-eight quarters. All data are seasonally adjusted.

D. Meyer-Glauber

John R. Meyer and Robert R. Glauber have proposed the fourth model to be considered in our study in their monograph, Investment Decisions, Economic Forecasting, and Public Policy [46]. The determinants of investment expenditures in the Meyer-Glauber model include capacity utilization, profits, and interest rates together with the percentage change in the price of common stocks. Pressure on capacity is measured by the ratio of the Federal Reserve Board index of industrial production [55] to the McGraw-Hill capacity series [4], interpolated from annual benchmarks using the OBE-SEC series on investment in the manufacturing sector. The profits variable is essentially the same as that employed by Anderson, profits after taxes minus dividends plus depreciation expense. The interest rate is Moody's AAA industrial bond rate [47] rather than the Treasury bill rate employed by Anderson. The theoretical basis of the model is similar to that proposed by Anderson and Duesenberry. The cost of funds schedule is assumed to depend on the availability of internal funds as well as the cost of external finance as reflected in the bond rate and the percentage rate of change of stock prices.

Meyer and Glauber employ a geometric lag to describe the time structure of the investment process as a whole. For each of the independent variables a separate fixed lag is determined; for example, profits are lagged one quarter while the bond rate is lagged three quarters. The average lag in the investment process for the variables lagged one quarter—profits, capacity utilization, and stock prices—is estimated at 8.7 quarters for total manufacturing. The average lag in the investment

\[11\] Further details are given in the Statistical Appendix; see footnote 6.
process for the interest rate, lagged three quarters, is 10.7 quarters. The shape of the distribution is rather peculiar, owing to the choice of two quarters rather than one quarter as the lag for investment expenditures as a dependent variable. There is no impact of change in profits, capacity utilization, and stock prices for one quarter. The impact in the first quarter is .207 of the long-run effect of the determinants of investment on the actual level of expenditures. There is then a quarter gap with no further impact, followed by an impact of .164, and so on with zero effects and geometrically declining effects for alternate quarters. The same type of lag distribution is taken to characterize each of the two-digit industries of manufacturing.

We now present a formal version of the Meyer-Glauber model, including the specification of the determinants of investment expenditures and of the time structure of the investment process. We let $I_t$ represent investment in constant prices; the model then takes the form:

$$ I_t = \beta_0 + \beta_1(T - V)_{t-1} + \beta_2 C^M_{t-1} + \beta_3 r_{t-3} + \beta_4 \left( \frac{\Delta SP}{SP} \right)_{t-1} + \beta_5 I_{t-2} + \beta_6 Q_1 + \beta_7 Q_2 + \beta_8 Q_3 + \epsilon_t. $$

The variable $T - V$ is net profit plus depreciation expense less dividends; it corresponds to Anderson's RED. The profits variable is derived from the FTC-SEC Quarterly Financial Report [61]. The variable $C^M$ is the ratio of production to capacity, where production is measured by the Federal Reserve Board index of industrial production and capacity by the McGraw-Hill capacity index. The variable $r$ is Moody's corporate bond rate; $SP$ is Standard and Poor's index of the prices of 425 industrials [52]; $\Delta SP/SP$ is the percentage rate of change of this price index. The variables $Q_1, Q_2,$ and $Q_3$ are seasonal dummy variables, as in Anderson's model. Meyer and Glauber have fitted the econometric model (2) to quarterly data for the same thirteen industry groups used in Anderson's study. The sample period for the Meyer-Glauber study extends from the first quarter of 1950 to the last quarter of 1958, a total of thirty-six quarters.

3. FRAMEWORK FOR THE STUDY

The four econometric models of investment behavior proposed by Anderson, Eisner, Jorgenson and Stephenson, and Meyer and Glauber are summarized in Table I. The determinants of investment expenditures are similar in the Anderson and Meyer-Glauber models; both include variables representing capacity utilization, profits, and the rate of interest. Anderson also includes debt capacity and variables representing requirements for liquidity. Meyer and Glauber include the percentage rate of change of stock market prices. Eisner bases the explanation of investment expenditures on past changes in sales, modified by the effects of past changes in profits as an indicator of changes in profit expectations. Jorgenson and

\footnote{These empirical results are based on the fitted investment function given by Meyer and Glauber [46, p. 153].}
### TABLE 1

**Comparison of Alternative Investment Functions**

<table>
<thead>
<tr>
<th>Determinants of Investment Behavior</th>
<th>Time Structure of the Investment Process</th>
<th>Data and Time Period of the Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson</td>
<td>Four quarter moving average of each of the determinants used as independent variable; time trend included to represent lag in expectations; decision lag taken to be fixed.</td>
<td>Undeflated data, not adjusted for seasonal variation; quarterly dummy variables included as independent variables; first quarter, 1949, to fourth quarter, 1958.</td>
</tr>
<tr>
<td>Eisner</td>
<td>Weight of first lagged change in sales and profits arbitrary; remaining weights declining geometrically.</td>
<td>Deflated data, adjusted for seasonal variation; third quarter, 1948, to fourth quarter, 1960.</td>
</tr>
<tr>
<td>Jorgenson-Stephenson</td>
<td>General Pascal distributed lag function.</td>
<td>Deflated data, adjusted for seasonal variation; first quarter, 1949, to fourth quarter, 1960.</td>
</tr>
</tbody>
</table>

- **Anderson**: Capacity utilization, profits, interest rate, stocks of government securities, accrued tax liability, debt capacity.
- **Eisner**: Change in sales, change in profits, capital stock.
- **Jorgenson-Stephenson**: Change in value of output divided by price of capital services, capital stock.
- **Meyer-Glauber**: Capacity utilization, profits, interest rate, percentage change in securities price index.
Stephenson combine the effects of past changes in output levels with changes in the price of capital services. Both Eisner and Jorgenson-Stephenson represent the determinants of replacement investment separately from the determinants of investment for expansion of capacity. All four econometric models of investment behavior are based on a dynamic version of the neoclassical theory of the firm. This theory is approximated through the marginal efficiency of investment schedule by Anderson and Meyer and Glauber. It is approximated through the demand for capital services by Jorgenson and Stephenson and by Eisner. These two alternative conceptualizations of the neoclassical theory are, of course, equivalent. (See [34, pp. 147–151].)

We conclude that there is no fundamental disagreement about the theory of the firm underlying alternative specifications of econometric models of investment behavior. The objective of the firm is to maximize discounted profits or good will subject to a technological constraint. Optimization subject to given technological possibilities gives rise to a demand function for investment goods, the marginal efficiency of investment schedule, or equivalently, to a demand function for capital services, the usual factor demand schedule. The cost of capital is one of the determinants of the demand for investment goods or the demand for capital services. Alternative specifications of econometric models of investment behavior differ mainly in representation of the cost of capital and its effects on investment behavior. In the Anderson and Meyer-Glauber models the flow of internal funds and the interest rate are among the determinants of the cost of capital. To these are added stock market prices in the Meyer-Glauber model and liquidity considerations in the Anderson model. Financial factors play a minor role in Eisner's model of investment behavior, entering only through changes in profit expectations. In the Jorgenson-Stephenson model the cost of capital is represented explicitly and becomes a determinant of investment expenditures through the price of capital services.

Proper representation of the time structure of investment behavior is given considerable attention in the four econometric studies of investment expenditures we have considered. All four studies allow for the possibility of a geometrically declining effect of changes in the determinants of investment behavior. The Eisner and Meyer-Glauber models are based explicitly on a Koyck distributed lag function. The distributed lag function used by Jorgenson and Stephenson contains the Koyck distributed lag as a special case. Anderson includes the Koyck distributed lag as one of three possible characterizations of the lag structure underlying investment behavior. So far as empirical results are concerned, a comparison of results at the aggregate level of total manufacturing reveals surprising uniformity. The average lag from changes in the determinants of investment to actual expenditures is 6.5 quarters for the Anderson model, using a geometric distributed lag function; it is 8.5 quarters for the Jorgenson-Stephenson model using a general Pascal distributed lag function; finally, this lag is 8.7 quarters for all determinants of investment but the interest rate in the Meyer-Glauber

\[^{13}\text{The empirical results for the Jorgenson-Stephenson model are presented in [39, p. 21, Table 2, second column].}\]
model. These estimates may be compared with Thomas Mayer’s estimate [45] from survey data of seven quarters for new manufacturing plants. Even the shape of the underlying distributed lag function is similar for investment functions as different as those of Anderson and Jorgenson and Stephenson. In the Anderson study there is no effect of changes in the determinants of investment until four quarters after the change has occurred. The effect gradually rises to a peak reached seven quarters after the change and declines geometrically thereafter. In the Jorgenson-Stephenson study of total manufacturing, the effect on investment expenditures also begins four quarters after the change and rises to a peak in seven quarters; the effect declines at a rate which becomes geometric asymptotically.\(^\text{14}\)

Finally, the implementation of the alternative econometric models differs slightly in detail. Anderson uses undeflated data while the other three studies use deflated data. Accordingly, we have transformed Anderson’s model (1) by dividing all variables on the right hand side by the investment goods price index, obtaining a model for the determination of investment in constant prices. Second, the Eisner and Jorgenson-Stephenson studies are based on seasonally adjusted data while the Anderson and Meyer-Glauber studies are based on unadjusted data. We use seasonally adjusted data for all comparisons. We fitted investment functions for the Anderson and Meyer-Glauber models including and excluding seasonal dummy variables; the seasonal dummy variables are not significant. Finally, the four studies are based on data from the third quarter of 1948 to the fourth quarter of 1960. We require data for the first eight quarters of the period since 1947 to implement the alternative characterizations of the time structure of the investment process. Accordingly, our study begins in the first quarter of 1949, the same as the Anderson and Jorgenson-Stephenson studies, later than the Eisner study and earlier than the Meyer-Glauber study. In order to include data not used in specifying the models we extended the time period of our study to the fourth quarter of 1964, adding sixteen new observations to the Eisner and Jorgenson-Stephenson studies, twenty-four observations to the Anderson study, and twenty-eight observations to the Meyer-Glauber study. We estimate investment functions based on each model for all fifteen of the subindustries of manufacturing for which data are published in the OBE-SEC Survey. These industries are listed in Table II; the industry groups from the Standard Industrial Classification\(^\text{15}\) included in each OBE-SEC Industry are also listed.

The alternative investment studies differ in one further respect. Anderson and Jorgenson and Stephenson determine a different lag structure for each industry group while Meyer and Glauber use the same specification of the lag structure for all industries. Eisner’s specification of the lag structure for investment realizations is the same for durables and nondurables manufacturing. The estimated time structure for each industry may differ, of course, depending on the values assumed by the parameters of the lag distribution even for a given specification of the form of this distribution. In Anderson’s study one form of the lag distribution

\(^{14}\) These empirical results are given by Jorgenson and Stephenson [39, p. 21, Table 2, second column].

\(^{15}\) The Standard Industrial Classification is taken from The Standard Industrial Classification Manual [60].
TABLE II
INDUSTRIAL CLASSIFICATION

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proved to be best for ten of the thirteen industry groups included in this study. The alternative forms chosen by Jorgenson and Stephenson for individual industry groups do differ but not markedly. To provide a better comparison between the Anderson and Jorgenson-Stephenson models on the one hand and the Eisner and Meyer-Glauber models on the other the same form of lag distribution was fitted to each industry group for the Anderson and the Jorgenson-Stephenson models; in each case the form was chosen as the one that proved best at the level of total manufacturing. For Anderson’s model this form was also best for ten out of the thirteen industry groups while for the Jorgenson-Stephenson model it was best for only six of the fifteen industry groups included in their study.

We turn now to the selection of a mechanical forecasting scheme to be used as a standard for performance of the econometric models. The standard implicit in the coefficient of multiple determination, frequently used as a measure of goodness of fit for econometric models, is that the observations are drawn from a fixed distribution and each drawing is independent of the preceding ones. Even a rudimentary examination of quarterly time series on investment expenditures reveals that successive quarterly observations are not independent; the first requirement for a mechanical forecasting scheme is that it exploit the serial dependence evident in the time series. Many “naive” models based on the serial dependence of economic time series have been proposed. For example, investment may be taken to be equal to its own past values, $I_t = I_{t-1} + \varepsilon_t$; alternatively, the change in investment may be taken to be equal to the past change,

$$I_t = I_{t-1} + (I_{t-1} - I_{t-2}) + \varepsilon_t.$$

A mechanical forecasting scheme that includes these two naive models and many others as special cases is a fourth-order autoregressive scheme:

$$I_t = \beta_0 + \beta_1 I_{t-1} + \ldots + \beta_4 I_{t-4} + \varepsilon_t.$$
We first fit this autoregressive scheme to data for each industry group; we then compare the econometric models and the autoregressive scheme with regard to goodness of fit. This standard for performance is especially appropriate for econometric models of investment since three of the four models included in our study use lagged values of investment expenditures as a means of characterizing the time structure of the investment process. Superiority of a fitted investment function to an autoregressive scheme provides an indication of the validity of the specification of the determinants of investment behavior other than those that characterize the time structure.

Finally, the OBE-SEC Investment Survey includes data on anticipated as well as actual levels of investment expenditures. The anticipations data are widely employed for forecasting purposes. A useful by-product of an evaluation of econometric models with each other and with mechanical forecasting schemes is a comparison of the best econometric model with a model for explaining investment on the basis of past anticipations of investment expenditures. If an econometric model can be found that provides a better explanation of investment than anticipations data, it would be difficult to justify the expense of a survey of investment anticipations. To evaluate the anticipations data from this point of view, we fit a regression of investment on earlier anticipations of investment expenditures; the model takes the form:

\[ I_t = \beta_0 + \beta_1 A_t + \ldots + \beta_4 A_{t-3} + \epsilon_t. \]

In this model \( A \) is the level of investment expenditures anticipated one quarter hence. Investment and anticipated investment expenditures are deflated by the price of investment goods for the quarter in which they are reported.

All of the investment functions included in our study were fitted to data on investment expenditures by ordinary least squares. In every model the values of the independent variables are lagged relative to the values of investment expenditures; provided that error terms in equations determining these variables are correlated with error terms in the investment functions only for contemporaneous values, the usual specification of econometric models,\(^\text{16}\) the possibility of simultaneous equations bias is eliminated by the specification of the time structure of the investment process. We conclude that the stochastic specification used in the original studies should be retained for our comparative study. Accordingly, we estimate each of the alternative investment functions by ordinary least squares.\(^\text{17}\)

4. EMPIRICAL RESULTS

We turn now to the empirical part of our study. First, we fit an investment function corresponding to each econometric model to quarterly data on investment

\(^{16}\) See, for example, Zelner and Theil [62, p. 57].

\(^{17}\) This method of estimation would be equivalent to two-stage least squares or limited information maximum likelihood estimation of the investment functions in a simultaneous equations model that is block-recursive with investment in the lowest-order block. This is the specification of the Brookings quarterly econometric model; see Duesenberry and Klein [8, p. 28].
expenditures from the OBE-SEC Survey for the period from the first quarter of 1949 to the fourth quarter of 1964. Investment functions are fitted for each of the fifteen industry groups for which data are reported in the OBE-SEC Survey. Investment functions based on regressions of investment on its own past values and on anticipatory data are also fitted for each industry group. Second, we compare the alternative econometric models with respect to their ability to explain quarterly data at the level of individual industry groups. As a standard for performance of all the econometric models we compare them with an autoregressive scheme. Finally, to appraise the usefulness of anticipatory data for explaining investment expenditures, we compare the explanatory power of these data with that of the econometric models and the autoregressive scheme.

Goodness of fit statistics for each investment function are given in Table III. Three measures of goodness of fit are presented. The coefficient of multiple determination, \( R^2 \), not corrected for degrees of freedom, is given in the first column of each part of the table. For example, the coefficient of multiple determination of Primary Iron and Steel is .4631 for the Anderson model, .8047 for the Eisner model, .8451 for the Jorgenson-Stephenson model, and .6853 for the Meyer-Glauber model. Similarly, the coefficient of multiple determination for this industry is .8517 for a fourth-order autoregressive scheme and .8999 for a regression of investment on past values of anticipated investment expenditures. The second column of Table III gives estimates of the standard error of the fitted regression residuals, \( s \), corrected for degrees of freedom. For Primary Iron and Steel the estimated standard error is .0573 for the Anderson model, .0342 for the Eisner model, .0307 for the Jorgenson-Stephenson model, .0431 for the Meyer-Glauber model, .0286 for the autoregressive scheme, and .0215 for the regression of investment on anticipatory data. The statistic contained in the second column is, of course, that relevant for measurement of the explanatory power of alternative models. Finally, as a measure of autocorrelation of the residuals, the Durbin-Watson ratio, \( d \), is given in the third column of Table III. As an example, this ratio is .6360 for the Anderson model for Primary Iron and Steel; for the Eisner model it is 1.576; it is 2.256 for the Jorgenson-Stephenson model, .6330 for the Meyer-Glauber model, 1.987 for the autoregressive scheme, and 1.633 for the regression of investment on anticipated investment expenditures.

The test for autocorrelation of errors based on the Durbin-Watson ratio is biased toward randomness for fitted regressions containing a lagged value of investment expenditures—the Eisner, Jorgenson-Stephenson, and autoregressive models.\(^{18}\) The conventional method for eliminating autocorrelation by means of an autoregressive transformation generates a regression function with more than one lagged value of each of the independent variables and one or more lagged values for the dependent variable as in the Eisner, Jorgenson-Stephenson, and autoregressive models. In effect, the inclusion of lagged investment expenditures in these models eliminates autocorrelation of the errors in advance; there is no need to test for the presence of autocorrelation. The sampling theory for the

\(^{18}\) See, for example, Griliches[23] and Malinvaud [44].
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<tr>
<td>Textile Mill Products</td>
<td>.8745</td>
<td>.0119</td>
<td>1.9501</td>
<td>.9461</td>
<td>.0063</td>
<td>1.4097</td>
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<tr>
<td>Paper and Allied Products</td>
<td>.9200</td>
<td>.0093</td>
<td>1.8302</td>
<td>.9419</td>
<td>.0075</td>
<td>1.4659</td>
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<tr>
<td>Chemicals and Allied Products</td>
<td>.8570</td>
<td>.0227</td>
<td>2.0645</td>
<td>.9122</td>
<td>.0153</td>
<td>1.8957</td>
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<tr>
<td>Petroleum and Coal Products</td>
<td>.6262</td>
<td>.0576</td>
<td>1.9159</td>
<td>.7563</td>
<td>.0415</td>
<td>1.2247</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rubber Products</td>
<td>.7566</td>
<td>.0046</td>
<td>1.9690</td>
<td>.7632</td>
<td>.0040</td>
<td>1.2779</td>
<td></td>
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<tr>
<td>Other Nondurables</td>
<td>.7141</td>
<td>.0121</td>
<td>1.8156</td>
<td>.8581</td>
<td>.0086</td>
<td>1.5185</td>
<td></td>
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</tbody>
</table>
least squares estimator is the same whether a model of the Eisner or Jorgenson-Stephenson type is generated by means of an autoregressive transformation or from a distributed lag function. In particular, estimates of the regression coefficients, their sampling variances, and the variance of the regression are consistent and unbiased, at least asymptotically, which is all that we require for the comparisons given in the following section. Of course, if an autoregressive transformation is used to generate a model of this type, the regression function is over-identified so that ordinary least squares is no longer asymptotically efficient; whether alternative methods of estimation are more efficient in samples of finite size is unknown.19

5. COMPARISON

We are now in a position to appraise the validity of the specifications of alternative econometric models of investment behavior on the basis of goodness of fit and absence of autocorrelation of the underlying errors. We can also evaluate the performance of econometric models by comparing each one with an autoregressive scheme. Finally, we can judge the worth of surveys of anticipated investment expenditures as a means of explaining actual investment behavior. A comparison of the models on the basis of goodness of fit, as measured by the standard error of the regression for each model,20 is given in Table IV. Investment functions corresponding to each econometric model have been fitted to each of fifteen industry groups. The number of industries for which a given model provides a superior explanation to each alternative model is indicated in each row of Table IV.

<table>
<thead>
<tr>
<th></th>
<th>Anderson</th>
<th>Eisner</th>
<th>Jorgenson-Stephenson</th>
<th>Meyer-Glauber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson</td>
<td>—</td>
<td>0 to 15</td>
<td>1 to 14</td>
<td>4 to 11</td>
</tr>
<tr>
<td>Eisner</td>
<td>15 to 0</td>
<td>—</td>
<td>4 to 11</td>
<td>13 to 2</td>
</tr>
<tr>
<td>Jorgenson-Stephenson</td>
<td>14 to 1</td>
<td>11 to 4</td>
<td>—</td>
<td>14 to 1</td>
</tr>
<tr>
<td>Meyer-Glauber</td>
<td>11 to 4</td>
<td>2 to 13</td>
<td>1 to 14</td>
<td>—</td>
</tr>
</tbody>
</table>

Considering the results presented in Table IV, we see that the Anderson model provides a better explanation of investment behavior than the Jorgenson-Stephenson model for only one industry group—Rubber Products. For the other fourteen

19 Asymptotically efficient methods of estimation for a model generated by an autoregressive transformation are given by Durbin [9] and Hall and Jorgenson [26]. These procedures give rise to tests for autocorrelation of errors that are valid even in the presence of lagged values of the dependent variable among the independent variables. See Hall and Jorgenson [26] for further discussion.

20 This comparison may be justified by Theil's method of specification analysis. See, for example, [54, Appendix 6.B, pp. 326–34].
industry groups the explanation provided by the Jorgenson-Stephenson model is superior. Similarly, the Anderson model provides a better explanation of investment behavior than the Eisner model for no industry groups; the explanation provided by the Eisner model is superior for all fifteen industries. Finally, the explanation given by the Anderson model is superior to that of the Meyer-Glauber model for four groups—Primary Nonferrous Metal, Motor Vehicles and Equipment, Transportation Equipment excluding Motor Vehicles, and Rubber Products. The Meyer-Glauber model provides a better explanation for the remaining eleven industry groups. We have already given a comparison of the performance of the Eisner and Anderson models. The Eisner model provides a better explanation of investment expenditures than the Jorgenson-Stephenson model for four industry groups—Transportation Equipment, excluding Motor Vehicles, Food and Beverages, Textile Mill Products, and Rubber Products. For the remaining eleven industry groups the explanation provided by the Jorgenson-Stephenson model is superior. The Meyer-Glauber model provides an explanation of investment behavior superior to that of the Eisner model for two industries—Other Durables and Textile Mill Products. The Eisner model provides a better explanation of investment behavior for the thirteen remaining industry groups. Finally, the Jorgenson-Stephenson model provides an explanation of investment behavior that is superior to that of the Meyer-Glauber model for fourteen of the fifteen industries. The Meyer-Glauber model is superior for one industry—Textile Mill Products.

On the basis of the comparisons given in Table IV an unambiguous ranking of the alternative econometric models of investment behavior emerges. The best explanation of quarterly investment behavior at the level of individual sub-industries of manufacturing is provided by the Jorgenson-Stephenson model. This model is superior to the Anderson model for fourteen of the fifteen industry groups included in our study. It is superior to the Meyer-Glauber model for fourteen of the fifteen industry groups and to the Eisner model for eleven industry groups. The second-ranking model on the basis of explanatory power is the Eisner model. It is superior to the Meyer-Glauber model for thirteen industry groups and to the Anderson model for all industry groups. Finally, the Meyer-Glauber model is superior to the Anderson model by a margin of almost three to one. This ranking may be summarized as follows: (i) Jorgenson-Stephenson, (ii) Eisner, (iii) Meyer-Glauber, (iv) Anderson.

A final comparison among the econometric models of investment behavior may be made by considering the evidence for autocorrelation of errors in the underlying statistical model. We have already observed that autocorrelation is eliminated in the Eisner and Jorgenson-Stephenson models through the inclusion of lagged values of the dependent variable in the fitted regressions; only the Anderson and Meyer-Glauber models may be misspecified through the presence of autocorrelated errors. The Durbin-Watson statistics given in the third column under Anderson and under Meyer-Glauber in Table III give clear evidence of positive autocorrelation of errors for both models. This evidence strongly suggests that the time structure of the investment process is misspecified in both of these
models, accounting in part for observed deficiencies in their explanatory power. We conclude that this evidence on the specification of the time structure of the investment process strengthens the inferences we have drawn on the basis of goodness of fit statistics.

The second comparison of interest for the purposes of this study is between econometric models and an autoregressive scheme. An autoregressive scheme provides a purely mechanical alternative to econometric models of investment behavior; a minimum standard of performance for an econometric model is that it should provide a better explanation of investment expenditures than an autoregressive scheme. For quarterly data on investment expenditures this standard for performance is quite stringent; the results of a comparison of explanatory power between an autoregressive scheme and the econometric models included in our study is given in Table V.

**TABLE V**

<table>
<thead>
<tr>
<th></th>
<th>Anderson</th>
<th>Eisner</th>
<th>Jorgenson-Stephenson</th>
<th>Meyer-Glauber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autoregressive</td>
<td>14 to 1</td>
<td>8 to 7</td>
<td>4 to 11</td>
<td>9 to 6</td>
</tr>
<tr>
<td>Anticipations</td>
<td>15 to 0</td>
<td>14 to 1</td>
<td>13 to 2</td>
<td>15 to 0</td>
</tr>
</tbody>
</table>

The first row of Table V indicates the number of industry groups for which the autoregressive scheme has explanatory power superior to that for each econometric model. The autoregressive scheme is superior to the Anderson model for fourteen out of fifteen industry groups. Similarly, the autoregressive scheme is superior to the Meyer-Glauber model for nine of fifteen industry groups. The Eisner model is superior to the autoregressive scheme for seven of fifteen industry groups while the Jorgenson-Stephenson model is superior for eleven of fifteen industries. We conclude that only one of the econometric models included in our study are superior to an autoregressive scheme in explaining quarterly data on investment expenditures. The explanatory power of the Eisner model is slightly worse than that of an autoregressive scheme while the explanatory power of the Jorgenson-Stephenson model is superior for eleven of fifteen industries. Errors in specification of the Anderson and Meyer-Glauber models made evident through the presence of autocorrelated error terms have very serious consequences for the performance of these models. Neither of these models is superior in explanatory power to a purely mechanical explanation of investment. Despite the fact that any autocorrelation of errors present in the Eisner model is eliminated through the representation of the time structure of the investment process, this model provides an explanation of investment expenditures that is only slightly better than the purely mechanical explanation provided by an autoregressive scheme. Only the Jorgenson-Stephenson model provides an explanation of investment that is clearly superior to a purely mechanical explanation.
Finally, the explanation of investment behavior provided by anticipatory data can be compared with that provided by econometric models on the basis of data presented in Table III. The results are given in the second row of Table V. Not unexpectedly, the anticipatory data provide an explanation of actual investment expenditures that is superior to that provided by econometric models for all but a very few of the fifteen industries. The performance of these data provides a clear indication of the value of the anticipation surveys. No econometric model currently available can compete with the anticipated investment data in explanatory power. The anticipatory data are superior to the autoregressive scheme for all fifteen industry groups, again a clear indication of the value of surveys of anticipated investment expenditures.

6. CONCLUSION

Our review of the literature in Section 2 demonstrated that at the most abstract level, econometric models of investment behavior do not differ with respect to their underlying theoretical framework. All four models are based on an intertemporal theory of the firm in which investment behavior is ultimately a consequence of production decisions. The models differ in two important respects: first, the specification of the time structure of the investment process differs widely from one model to another; second, the determinants of the cost of capital and the relative importance of specific financial factors in the determination of investment behavior also differs considerably from one model to another.

Our evaluation of the Anderson and Meyer-Glauber models reveals clear evidence of misspecification, both in the relatively lackluster performance of these models in explaining data on investment expenditures and in the indication of autocorrelation in the errors of the underlying statistical model. The distributed lag functions employed in the Eisner and Jorgenson-Stephenson models are clearly superior to those employed by Anderson and by Meyer and Glauber. The distributed lag function employed by Jorgenson and Stephenson includes that of Eisner as a special case; the use of a general Pascal lag distribution undoubtedly accounts for part of the margin of superiority of the Jorgenson-Stephenson model. However, for many of the industries for which the Jorgenson-Stephenson model is superior to the Eisner model, the lag structure effectively reduces to that for an ordinary geometric distributed lag function, so that a good part of the superiority of the Jorgenson-Stephenson model may be traced to the specification of the underlying determinants of investment expenditures.

In view of the importance of correct specification of the time structure of the investment process it is difficult to evaluate the alternative treatments of the determinants of investment behavior represented by the econometric models in our study. The continuity in investment programs is sufficiently great from quarter to quarter that a relatively large proportion of investment expenditures corresponds to the effects of changes in the underlying determinants of investment that occurred at an earlier point in time rather than the value of these determinants represented
explicitly in the econometric model. Accordingly, studies of quarterly time series even at the level of individual industry groups are unlikely to provide sharp discriminations among alternative specifications of the determinants of investment behavior.

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University of California, Berkeley,
and
Columbia University and National Bureau of Economic Research

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[2] ———: Corporate Finance and Fixed Investment, Division of Research, Graduate School of Business Administration, Harvard University, Boston, 1964.


21 See, for example, the representation of the investment process given by Jorgenson and Stephenson [38, p. 191].

22 This view is supported by the study of Griliches and Wallace [24], comparing an investment function similar to that of Jorgenson and Stephenson with an investment function based on the same lag structure but with expected profit as measured by stock market value as the determinant of investment expenditures, a model originally proposed by Grunfeld [25]. A study of the investment of individual firms has been completed by Jorgenson and Siebert [35, 36]; this study provides considerably sharper discrimination among alternative determinants of investment behavior.


