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MANAGERIAL AND STOCKHOLDER WELFARE MODELS OF FIRM EXPENDITURES

Henry G. Grabowski and Dennis C. Mueller *

THIS study investigates within a common analytical framework the determinants of firm expenditures on capital investment, research and development and dividends. Its two basic objectives relative to past work are: first, to probe more deeply into the forces determining these outlays by taking into account the interdependencies among them,¹ and second, to provide a framework for evaluating alternative assumptions regarding firm motivation. A firm maximizing stockholder objectives will exhibit different behavior in its expenditure decisions from one pursuing managerial goals. Consequently, two main variants of a model of firm expenditures, based on these rival concepts of motivation, are developed and tested.

I Development of the Models

One has reason for expecting on theoretical grounds that a general interdependence exists between the various alternative uses of investment funds. Whether managers maximize stockholder or their own personal objectives, they must weigh the expected marginal returns from any activity relative to competing and complementary uses of funds both within and outside the firm. These basic tradeoffs, adapted to alternative goal structures, underly the analysis of the interactions among the three key decision variables — R and D, capital investment, and dividends. In principle, one also expects some interdependence between these activities and other investment-type outlays, e.g., advertising and external acquisitions. The

latter investment activities are ignored largely because of data insufficiencies. Since these activities are quantitatively of less importance for our sample of firms than the outlays actually studied, their omission is mitigated.²

Empirically testable models of firm expenditures are constructed in the following section alternatively based on managerial and stockholder objectives.

A) *The Managerial Model*

Of the many managerial theories that have appeared in recent years, we employ one that focuses on investment and dividend decisions. It draws most directly from the work of Robin Marris (1964). The hypothesis that a manager's pecuniary and nonpecuniary compensation is more closely tied to firm size than profitability is central to this and most previous managerial models. Consequently, managers are envisaged as pushing investment programs to a point where their marginal rate of return is below the level which would maximize stockholder welfare. While external capital sources can be used, internal funds are expected to be particularly favored because they are the most accessible part of the capital market and most malleable to managerial desires for growth. Thus, a major component of the managerial theory is the hypothesis that a greater percentage of internal funds are retained and invested than are warranted to maximize stockholder welfare.³

Nevertheless, a growth oriented management cannot be totally insensitive to the capital market reactions of its investment policies. At

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* A first draft of this paper was presented at the Econometric Society Meetings in December 1969. Thanks are due to Robert Eisner and Guy V. G. Stevens for their very helpful suggestions. Burton Malkiel provided us with some data on corporate risks. Research was supported by National Science Foundation Grants GS-2677 and GS-2678.

¹ There have been to date a handful of studies attempting to look at these types of decisions in a simultaneous decision-making framework (Anderson, 1964) (Dhrymes and Kurz, 1967) (Mueller, 1967). In particular our analysis extends both theoretically and empirically a previous study by one of the authors (Mueller, 1967).

² Data are available for some expenditure decisions — e.g., investment in liquid capital assets — which are not included as interdependent activities but rather treated as having lower priority in the hierarchy of firm decisions.

³ Investment opportunities may be so promising that all internal funds can be exhausted without pushing the marginal rate of return below the stockholders' opportunity cost. No conflict between the managerial and stockholder-oriented firm regarding retention policies then exists. Elsewhere one of the authors has argued that this is most characteristic of firms in the early stages of their life cycle and is likely to pass with time (Mueller, forthcoming).

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the point where the marginal returns on investment fall below the stockholder's opportunity cost, the firm's stock price starts to fall.⁴ The firm becomes more vulnerable to a takeover from outsiders as its market valuation falls increasingly below its potential value, thereby tempering the managers' use of internal funds. In effect, some dividends will probably be made because they yield utility to the managers by increasing their security against a takeover.⁵

Taking this desire for security into account, the managers' objective function becomes a blend of managerial, (growth) and stockholder (valuation) goals. In terms of the three expenditures under study, this implies a utility tradeoff between more growth producing R and D and investment, on the one hand, and more security producing dividend payments on the other. A dominant weight on security will produce policies approximating those that maximize stockholder welfare, while an aggressively growth-oriented management completely unconcerned about a takeover will reinvest nearly all earnings and pay little or no dividends. Our model implicitly assumes managers are somewhere between these two extremes.⁶

In equilibrium, the managers should equate the marginal returns from the three expenditures expressed in units of utility, to the mar-

ginal cost or disutility of financing an additional outlay on any of them. The managerial firm's equilibrium conditions then can be written as

$$mrr_R = mrr_I = mrr_D = mcf, \quad (1)$$

where

R — R and D expenditures

I — Fixed capital investment expenditures

D — Cash dividend payments.

We postulate further that

$$\begin{aligned} mrr_R &= a_r + b_R I + c_R R + e_R X_R, \\ mrr_I &= a_I + b_I I + c_I R + e_I X_I, \\ mrr_D &= a_D + b_D I + c_D R + d_D D + e_D X_D, \\ mcf &= g(R + I + D) + hZ. \end{aligned} \quad (2)$$

where each X is a set of exogenous variables peculiar to the given investment activity and Z is a single set of exogenous variables which determines the marginal cost of capital.

A linear formulation for the marginal rate of return and cost of finance functions can be shown to follow exactly from a quadratic utility function or alternatively may be regarded as an approximation to more complex functional forms. Moreover, it facilitates the econometric estimation of our models by allowing the use of standard linear simultaneous equation estimation techniques.

Many of the signs on the coefficients in (2) can be predicted from the underlying theory. The c_R and b_I coefficients in the mrr_R and mrr_I equations are expected to be negative owing to the law of diminishing returns. The more R and D undertaken the lower the expected returns from the marginal R and D project are likely to be. The impact of the alternative investment programs on the marginal returns in each activity are more difficult to predict. On the one hand an expansion of the R and D program may draw scarce managerial talent away from the firm's capital investment programs and thereby lower the expected returns from capital investment. More directly, it may speed up the obsolescence of the capital equipment currently installed also lowering mrr_I . Alternatively current R and D may lead to product improvements which increase the firm's image, expand the demand for its product(s) and raise the expected returns on some of its current investments in plant and equipment. Thus, b_R and c_I can be of either sign and could easily be of opposite signs.

The positive utility managers get from divi-

⁴This relationship has been well observed in the literature and runs counter to the stockholder welfare predictions of the Miller and Modigliani hypothesis. For a discussion of the importance of this finding for the managerial theories see (Mueller).

⁵Marris puts the most emphasis on the threat of takeover as the chief deterrent to managerial pursuit of growth through investment (Marris, 1964). Other variants of a managerial theory of the firm which stress a manager-stockholder conflict, and thus implicitly contain a managerial utility functional for paying dividends as a means of placating stockholders are developed in (Baumol, 1967) (Mueller, 1969) (J. Williamson, 1966) (O. Williamson, 1964).

⁶Lintner's famous discovery that managers tend to decide this year's dividend payment by slightly adjusting last year's payment, depending on current profits, is fully consistent with a managerial theory (Lintner, 1956). Once the stockholders get used to a given dividend payment they are not likely to challenge management's policies providing this payment is not dramatically curtailed and that it tends to move with profits. In the short run, therefore, managers essentially may determine dividends prior to investment, as a number of previous studies have implicitly assumed by regressing investment on cash flow net of dividends (Grabowski and Mueller, 1971) (Kuh, 1963) (Kuh and Meyer, 1957) (Marris, 1964). Over the long run, an interdependence between dividends and investment can be expected, however.

dends can be expected to diminish rapidly after some point. Therefore, d_D is assumed negative and large. Conceivably one could expect the coefficients of I and R to be of either sign in the mrr_D equation. If stockholders have optimistic expectations concerning a firm's internal investment opportunities an increase in I or R could increase the price of the outstanding shares and reduce the necessity to pay dividends. This would imply that b_D and c_D are negative. However, the main premise of our managerial theory is that managers push the rate of return on investment outlays below the rate that maximizes stockholders welfare thereby lowering the price of the firm's stock. This suggests that over the relevant range additional outlays on R and D and capital equipment will raise the managerial returns to paying dividends. Hence, we predict that if the managerial theory is to be supported, both b_D and c_D should be positive.

The marginal cost of capital is frequently assumed to be lower for internally raised funds than for external capital (Duesenberry (1958), (Kuh and Meyer (1957, pp. 87-97))). While in the context of a stockholder welfare maximizing model a sharp rise in the cost of capital function, at the point where it crosses over to outside funds, seems to impart a degree of irrationality to the managers, such a rapid increase is quite consistent with a managerial theory of motivation. The cost of using internal funds for management-oriented firms is not the rate of return the stockholders can earn in the market, but some much lower totally subjective value set by the managers. On the other hand, the subjective costs associated with external funds causes the managerial firm's cost of capital to increase over this portion of its marginal cost of finance (mcf) schedule. When it issues new stocks or bonds or increases bank borrowing, greater attention from the financial community is drawn to its investment and dividend policies. More importantly, the potential for a loss of control through financial insolvency increases when new bonds are issued or additional bank borrowing occurs. These subjective costs, reinforced by any capital market imperfections causing interest and transactions costs to increase with additional external funding, eventually must result in a rapidly rising cost of

capital over this segment of the managerial firm's mcf schedule.

In the long run, a management is almost certain to adopt investment, R and D , and dividend policies which use up all internal fund flows and bring the firm to some point on the rising stretch of the curve. Therefore, over the relevant range, any increase in expenditures will cause the cost of capital to increase. For this reason, the amounts of R , I , and D have been included as shift parameters each getting equal weight (since they are measured in the same money units) in the mcf equation. The shift parameter, g , will have a positive sign.

Normally, the marginal rate of return and marginal cost of finance schedules as set forth in equational set (2) cannot be directly observed. However, given the equilibrium conditions in (1), this system may be solved in a variety of ways which are empirically tractable. We regard it as most informative to do so by equating each of the marginal return functions in turn with the cost of finance function. Substituting from (2) into (1) and solving in this way we obtain

$$\begin{aligned}
 R &= \frac{a_R}{g - c_R} + \frac{b_R - g}{g - c_R} I - \frac{g}{g - c_R} D \\
 &\quad + \frac{e_R}{g - c_R} X_R - \frac{h}{g - c_R} Z, \\
 I &= \frac{a_I}{g - b_I} + \frac{c_I - g}{g - b_I} R - \frac{g}{g - b_I} D \\
 &\quad + \frac{c_I}{g - b_I} X_I - \frac{h}{g - b_I} Z, \\
 D &= \frac{a_D}{g - d_D} + \frac{c_D - g}{g - d_D} R + \frac{b_D - g}{g - d_D} I \\
 &\quad + \frac{e_D}{g - d_D} X_D - \frac{h}{g - d_D} Z.
 \end{aligned} \tag{3}$$

In this case each endogenous variable becomes a function of the other endogenous variables in the model, the set of exogenous variables which determines its marginal returns, and the set of exogenous variables which determines the cost of capital and is common to all equations. This finding is completely general, of course, and is not dependent upon the particular linear formulation employed here.

Given the specific form of our model, and the a priori predictions made concerning the parameters in (2), predictions about the signs of many of the variables in (3) can be made. Since g is assumed to be positive, and c_R , b_I

and d_D are all assumed negative, the denominators of all the coefficients in (3) have positive signs. This allows us to predict the signs of the coefficients of all of the exogenous variables unambiguously. It also allows us to predict the signs of two of the codetermined variables. Dividends should have a negative coefficient in both the R and D and capital investment equations. Since c_D and b_D are both assumed to be positive, the signs of the R and I coefficients are ambiguous in the dividends equation, as are the coefficients of R in the investment equation and I in the R and D equation. If the substitute aspects of the investment activities dominate ($b_R < 0$ and $c_I < 0$) then their respective coefficients in (3) are definitely negative. If the complementary aspects are most important, their coefficients will be positive or negative depending on whether b_R and c_I are greater than g . While we expect that the likelihood is that these coefficients will be negative, we cannot rule out the alternative possibility in either case.

An alternative to estimating (3) is to resolve it and completely eliminate R, I and D from the right-hand sides of the equations. This makes each dependent variable a function of *all* of the exogenous variables in the model and none of the other codetermined variables. Unbiased estimates of the parameters of this system can be obtained by using direct least squares. It is not possible, however, to make unambiguous predictions about the signs of these parameters based upon the predictions made regarding (2). For this reason, an algebraically simpler version of the model, like (3) is preferred, even though unbiased estimates of (3) can only be obtained using one of the simultaneous equation techniques. Two-stage least squares has been employed here.

B) *The Stockholder Welfare Maximization Model*

A firm maximizing stockholder welfare or market valuation should equate the marginal rate of return on each investment activity to its marginal cost of finance. The cost of internal funds is the stockholder's opportunity cost (i.e., the rate of return he could earn on another stock of comparable risk), and the cost of external funds is the market rate on

debt and new equity. If capital markets were perfect, which is assumed in the strictest neoclassical formulations of this model, Jorgensen and Siebert (1968), Modigliani and Miller (1958), the costs of capital on both external and internal sources are constant and equal. In this market situation, decisions regarding the optimal levels of investment are fully dichotomized from those regarding sources of finance. All investment activities should be undertaken to the point where their expected return equals the constant cost of capital. Since the cost of capital is invariant to the source of finance, the resulting level of investment may be financed by any combination of earnings plowback, debt or new equity without affecting market valuation.

A number of important implications for the structure of an expenditure model follow from the neoclassical theory. First, dividends are no longer codetermined with the other expenditure variables as in our managerial model, but rather are decided on some subsidiary or residual basis. Second, the level of cash flow, which is expected to be a major variable influencing the position of the managerial firm's mcf schedule and hence its investment expenditures, is irrelevant for the neoclassical firm's investment decisions. These are very strong hypotheses distinguishing the two approaches.

Because this neoclassical variant of the stockholder welfare model has received a great deal of prominence recently, both theoretically and empirically, and also because it offers the greatest differentiability from the managerial model, it will be the focus of our attention here. If the neoclassical model with its exclusion of all finance-related variables except stockholder opportunity cost, statistically outperforms the managerial model, this may be viewed as strong evidence against the managerial approach. Since a case can be made for introducing some of these variables into a stockholder welfare model by relaxing the extreme assumption about a perfect capital market,⁷ a strong per-

⁷ The nature of the expected relationships will depend on the shapes and positions of the firm's internal and external funds portions of its mcf curve. If the cost of capital on internal sources remains constant and is always below that on external funds (because of transactions costs), dividends will still be residually determined. Moreover, the total amount of cash flow will have an impact on the cost of capital only when investment opportunities are so prom-

formance of these variables is not necessarily incompatible with a stockholder welfare orientation of managers. Thus, a full discrimination between a stockholder welfare theory with capital market imperfections and the managerial models depends on isolating other differences in behavior or other independent evidence. After fully specifying and comparing the statistical performance of the managerial model with the strict neoclassical variant, the results will be evaluated from this wider perspective.

With dividends omitted as a codetermined variable and a constant cost of capital, we have as the equilibrium condition on the R and D and investment decisions for the neoclassical variant of the model

$$mrr_R = mrr_I = r \quad (4)$$

where r = *neoclassical firm's cost of capital*.

Linearizing the mrr_R and mrr_I equations as in equational system (3) above (of course the values of the coefficients and sets of exogenous variables may differ), and equating each of the marginal rates of return schedules in turn to the cost of capital, the following structural model is obtained

$$\begin{aligned} R &= \frac{a_R}{c_R} - \frac{b_R}{c_R} I - \frac{e_R}{c_R} X_R + \frac{r}{c_R} \\ I &= \frac{a_I}{b_I} - \frac{c_I}{b_I} R - \frac{e_I}{b_I} X_I + \frac{r}{b_I} \end{aligned} \quad (5)$$

The signs of all of the coefficients can be predicted except for the codetermined I and R variables. Equation (5) will be estimated using two different measures of r to be discussed below.

II The Exogenous Variables of the Managerial Model

In constructing the sets of exogenous variables, we follow an eclectic approach, borrowing freely from formulations of variables in past studies which have been primarily single equation in nature. Where problems of data availability and suitability arise, we tend to

use an imperfect measure of a particular effect rather than discard it entirely.

A) *The Rate of Return to Capital Investment Equation (the X_I set)*

The capital investment decision has been the most exhaustively examined firm expenditure of those investigated here. On the marginal rate of return side, past studies have emphasized demand pull considerations in the form of various accelerator variables (Eisner, 1967). Accordingly we incorporate changes in sales in the current and previous two periods as part of X_I in equation (3). No particular lag structure is imposed but rather the regression coefficients are allowed to specify the appropriate structure. Moreover, since the focus is on cross-sectional variations, these sales-change terms are weighted by each firm's average capital to sales ratio over the eight-year period under study, 1958–1966. This particular weighting scheme is based on the assumption that the firms on average were producing at or near full capacity over this period.

Because the level of *gross* investment is being investigated, another component of investment demand arises from the need to replace a depreciating capital stock. Depreciation and depletion flows, calculated on an accounting basis, are used as an imperfect proxy for replacement demand.

A third component of investment demand which has received much less attention in the literature is the induced demand generated from successful R and D of each firm. This is because the output from R and D, technological change in the form of new products and process, has been difficult to quantify in any meaningful way. One measure of the output from R and D which is admittedly imperfect, but has been used by Schmookler and others, is the number of patents granted over a particular period (Grabowski, 1968) (Scherer, 1965) (Schmookler, 1966). The advantages and limitations of patent statistics have been amply discussed elsewhere (Schmookler, 1966, chapter 2). Without going into the details of the discussion, we feel that patents can be a useful albeit partial measure of technological output, as long as any cross-section uses of it are confined to firms with similar product structure

using as to completely exhaust internal funds and force a resort outside capital. On the other hand, if both the internal and external segments exhibit an increasing slope and overlap over the relevant range of investment expenditures, a general interdependence will occur as in the managerial case.

and technologies (Comanor and Scherer, 1969) (Mueller, 1966). Therefore, a moving average of patent grants is included among the X_t set of variables.

B) *The Rate of Return to R and D Equation (the X_R set)*

The determinants of R and D have received far less attention in the literature. Work done to date suggests that R and D activity like other investment decisions is influenced by rate of return and cost of capital considerations, (Grabowski, 1968) (Mansfield, 1968) (Mueller, 1967) (Schmookler, 1966). In a prior single equation study, one of the authors found that past research productivity, as measured by the size of patented output per professional R and D employee, is a significant explanatory variable of current research intensity (Grabowski, 1968). Because of its success in this prior analysis and the absence of any better measures of technological output we continue to use this past productivity measure as an index of the firm's capacity to do successful R and D.

While our whole model is, in a fundamental sense, a test of the managerial theory of the firm, it also seems plausible that the *degree* of management control would have a discernible impact on the investment and growth policies of the firm.⁸ This hypothesis has been tested with respect to capital investment and advertising in previous studies by Williamson (1964) and Kammerchen (1970), with conflicting results. Hence, it seemed useful to place a measure of management control somewhere among our exogenous factors in the managerial model.

For both theoretical and statistical reasons, our index of management control is included in the mrr_R equation. In technologically progressive industries R and D is likely to be the investment activity having the greatest long run effect on growth, and hence can be expected to be particularly favored by management controlled firms. In addition, technological leadership has become a prestige symbol in some management circles and may be a recipient of some of the cash over which managers have discretionary control (Brittain, 1966). Hence,

⁸ Although, an absence of any relationship between the degree of management control and growth is not necessarily inconsistent with the growth hypothesis. For an elaboration of this point see (Mueller, 1970).

we predict the greatest positive impact for the management control variable will be in the R and D equation.

An analogous, although theoretically somewhat weaker case, can be made for including management control in the capital investment equation. Unfortunately if we include this variable in both the investment and R and D equations, the number of variables left to identify the capital investment equation is reduced sufficiently to introduce instability into the two-stage estimates for this equation. Therefore, we have had to be satisfied with an attempt to isolate the impact of this variable on the extreme growth-producing end of the investment spectrum.

As a measure of the degree of management control, we follow Williamson and employ the percentage of the board of directors who are also executives of the firm (Williamson, 1966). While it differs somewhat from Kammerchen's measure relating to the dissemination of stock ownership, both are positively and significantly correlated for the subset of our sample for which both measures are available.⁹

C) *The Rate of Return to Dividends (the X_D set)*

Most attempts to explain dividend payments adopt some variant of Lintner's basic model (Lintner, 1956) and employ profits or total cash flow and lagged dividends as explanatory variables (Brittain, 1966). This approach is not used here. While cash flow is an explanatory variable in our system through cost of capital factors, lagged dividends are not included in the model. Since the focus is on cross-sectional variations, the analysis must essentially center on the long-run management decision of the optimal dividend payout ratio. In this regard, to say that this year's payments are determined in large measure by last year's dividends, with a slight adjustment toward an unaccounted for long-run payout ratio, is not very enlightening.

⁹ The percentage of directors is more readily available and exhibits more variability than the conceptually somewhat more satisfying measure based on stock ownership. When one classifies the firms in our sample in a polar manner using stock ownership data, most fall into the management controlled rather than stockholder controlled categories. This will be true of any representative sample of large firms in the manufacturing sector.

In his original work, Lintner suggests as determinants of the payout ratio — the growth rate of the firm, the variability of its profits, and the payout ratio of its competitors in the capital market (Lintner, 1956). Some of the considerations expressed by these variables are captured directly in our model through the endogenous variables whose levels reflect alternative profit opportunities of investment within the firms rather than paying dividends. Following Lintner's hypothesis, however, we include as exogenous variables influencing inter-firm differences in dividend payouts, the firm's long-run growth in earnings per share over the eight-year period spanned by our samples, and its variability in earnings to net worth over this period.

It may be noted with Lintner's scheme, both of these variables are expected to have a negative effect on dividend outlays. While we definitely expect this to be the case for the growth rate variable, for a management-oriented model one would tend to expect higher variability in earnings to result in greater rather than less dividends. If dividends provide utility to the managers primarily by giving some security against the threat of loss of control, then higher variability in earnings will increase this threat if it produces lower stock prices and *ceteris paribus*, the managers should try to offset this with higher dividend payments. We thus predict a positive coefficient for this variable in the dividends' equation, and the accuracy of this prediction becomes another test of the managerial theory of the firm.

D) *The Marginal Cost of Finance Equation (the Z set)*

From the discussion of section I it is clear that the main exogenous variables determining the position of the vertical stretch of the cost of finance schedule are the components of its internal cash flows — after tax profits and depreciation and depletion charges. In addition to the theoretical justifications for including these cash flow variables, numerous studies have found them to be effective predictors of firm outlays. Following Meyer and Kuh (1957) a number of studies have appeared that include some measure of cash flow as an explanatory variable (Duesenberry, 1958) (Kuh,

1963) (Meyer and Glauber, 1964) (Mueller, 1967). Previous work on our part has indicated that these revenue flows are important determinants of expenditures on R and D (Grabowski, 1968) (Mueller, 1967) and advertising (Grabowski and Mueller, 1971). John Brittain's work also indicates that Lintner's results on dividends can be improved by a consideration of both profits and depreciation.

Managers are assumed to require some interval to process and evaluate information on cash flow, so these variables are included with a one-year lag. Furthermore, because after-tax profits are assumed to index funds available for R and D, investment and dividends *before* these decisions are made, 50 per cent of current R and D outlays are added to the reported profits figures. The United States tax provisions allowing R and D to be totally expensed produce an understatement of pre-R and D profits by roughly this amount.

Variables influencing the actual terms of external finance (the firm's level of indebtedness, the state of the capital markets, etc.) are not included. If, as suggested above, the managerial firm's mcf schedule exhibits a sharp upward discontinuity at the point where it obtains funds externally, these variables can be expected to have secondary and somewhat irregular impacts on firm decisions. Moreover, previous attempts to incorporate them into cross-section type studies have not met with encouraging results (Meyer and Glauber, 1964).

E) *The Managerial Variant in Operational Form*

All the exogenous variables to be used in the managerial model have now been specified. In symbolic notation, they are

1. X_t set
 $\Delta S_t, \Delta S_{t-1}, \Delta S_{t-2}$ — lagged and unlagged sales changes
 DP_{t-1} — depreciation and depletion charges in period $t-1$
 P_t — average number of patents awarded over a previous three-year period.
2. X_R set
 $(P/W)_t$ — the number of patents per professional scientific employee over a prior three-year period
 MC_t — percentage of a firm's directors who are also fulltime managers in period t .

3. X_D set
 - g — the growth in earnings per share over the period 1958–1966
 - σ_s — the standard deviation in earnings to net worth over the period 1958–1966.
4. Z set
 - π_{t-1} — profits after tax in period $t-1$
 - DP_{t-1} — depreciation and depletion changes in period $t-1$.

Before doing any empirical estimation, it is desirable to normalize many of the above variables with respect to some index of firm size. Failure to do so is likely to result in heteroscedasticity in the residuals as well as simple scale factors dominating the explanation of the cross-sectional variation in the endogenous variables (Kuh, 1963, pp. 91–96) (Mueller, 1967, p. 63). Accordingly, all size related variables both endogenous and exogenous, are deflated by sales and expressed as intensities (i.e., percentage of sales) rather than absolute quantities. While we have some a priori reasons for choosing sales as the deflator,¹⁰ this particular choice is not critical from an empirical standpoint. We ran all the equations using assets as a deflator and the results change only slightly.

A few of the variables (P/W and MC in the R and D equation and g and σ in the dividends equation) are not deflated by sales because they are already in ratio form and are in effect deflated by size related measures.

The managerial model previously set forth in equational system (3), may be expressed now in operational form as

$$\begin{aligned}
 \frac{R_t}{S_t} &= m_0 + m_1 \frac{I_t}{S_t} + m_2 \frac{D_t}{S_t} + m_3 \left(\frac{P}{W} \right)_t \\
 &\quad + m_4 MC_t + m_5 \frac{\pi_{t-1}}{S_t} + m_6 \frac{DP_{t-1}}{S_t} + \mu_{Rt} \\
 \frac{I_t}{S_t} &= k_0 + k_1 \frac{R_t}{S_t} + k_2 \frac{D_t}{S_t} + k_3 \frac{\Delta S_t}{S_t} \\
 &\quad + k_4 \frac{\Delta S_{t-1}}{S_t} + k_5 \frac{\Delta S_{t-2}}{S_t} + k_6 \frac{P_t}{S_t} \\
 &\quad + k_7 \frac{\pi_{t-1}}{S_t} + k_8 \frac{DP_{t-1}}{S_t} + \mu_{It} \\
 \frac{D_t}{S_t} &= n_0 + n_1 \frac{R_t}{S_t} + n_2 \frac{I_t}{S_t} + n_3 g + n_4 \sigma_s \\
 &\quad + n_5 \frac{\pi_{t-1}}{S_t} + n_6 \frac{DP_{t-1}}{S_t} + \mu_{Dt}
 \end{aligned} \tag{6}$$

¹⁰ Essentially we prefer sales to assets as a deflator in a cross-section analysis because it is a more "neutral" size measure. Since a significant positive relation between the capital intensity of the firm's production process and over-

where μ_{Rt} , μ_{It} , and μ_{Dt} are statistical error terms.

Collectively there are twenty coefficients to be estimated for the managerial model. We can predict the signs of sixteen of these, exempting only k_1 , m_1 , n_1 , which depend on whether substitutability or complementarity is dominant between the respective pairs of endogenous variables. For the other coefficients, our hypotheses suggest three will be negative (k_2 , n_2 , and n_3) with all the others positive.

III The Exogenous Variables: Stockholder Welfare Maximization

All the exogenous variables previously specified for the mrr_I and mrr_R equations (the X_I and X_R sets) are retained for our stockholder welfare maximization model, with the exception of the management control variable. Moreover, all the hypotheses concerning the direction of impact of these variables on the two investment decisions are also unaltered, although the expected magnitudes of the coefficients can be expected to differ under alternative motivational assumptions.

With dividends omitted as a codetermined variable in the neoclassical model, the X_D set of exogenous variables are dropped from the equational system.

The most fundamental difference between the two models, of course, is the replacement of the cash flow variables in the mcf equation by the neoclassical cost of capital variable, the stockholders opportunity cost. Jorgenson has used as a proxy for the stockholder opportunity cost variable, a measure based on the earnings to price ratio of the firm. This seems to us more a measure of stockholder expectations about future earnings than of outside investment opportunities (Eisner and Nadiri, 1968). Consequently, it is desirable to devise a measure of stockholder investment opportunity which tries to get directly at the alternative investment choices.

The basis for constructing an externally derived cost of capital depends on one's char-

all size has been observed, deflating by assets may introduce a definite bias. Nevertheless, our results tended to exhibit great similarity, irrespective of the size deflator, with slightly higher $\bar{R}^2$ and t values on most variables occurring in the sales deflated case.

acterization of the risks involved in holding an asset. We shall develop two concepts of stockholder opportunity cost that are tied to alternative views of risk. One is based on the variance of the stock's rate of return. The other is a covariance measure of risk designed to reflect how the security contributes to the overall variability in a diversified portfolio.

First, related to a variance concept of risk, an opportunity cost variable is constructed based on the rate of return realized by holding stock in firms in a comparable risk class. In order to construct such a rate of return variable, we made use of a study by Nerlove investigating the rates of return to stockholders (for a large sample of firms on the Compustat tape over the period 1950–1964 (Nerlove, 1968)). Nerlove's data were used to compute the annual rates of return from holding each stock (based on cash dividends and capital gains) on the assumption that the stockholder went in and out of the market each year, alternatively at the high and low price for the stock.¹¹ The greater the variance in these annual rates of return from holding the stock, the greater the likelihood a stockholder forced to sell might realize a return below a given percentage of the market average.

The 369 firms from Nerlove's sample for which data were available were then ranked according to this variance measure of risk, and grouped into risk classes consisting of the 30 firms in Nerlove's sample with realized rates of return closest to its own. The average rate of return of the 30 stocks in each firm's risk class is used as our estimate of the firm's neo-classical cost of capital, i.e., as the average return a stockholder could expect from investing in stocks of comparable risk. In our empirical work, this variable is denoted as r_1 . In contrast to our second measure, it is a time invariant measure for each firm over the eight-year period under study. Since the behavioral composition of a firm's shareholders changes only slowly, the assumed constancy over time of this vari-

able probably does not introduce any large errors.¹²

The alternative measure is based on a concept of portfolio risk, in accordance with a Markowitz type portfolio selection model. This approach argues that the rational investor neutralizes most of the variance risk through diversification leaving only a covariance component. The recent work of Sharpe and others generalizing this approach to a full theory of equilibrium in the capital markets provides a basis for empirical measurement of portfolio risk (Sharpe, 1964). Using Sharpe's analytical framework, one can regress each firm's rate of return, r_f , on some overall market average, r_m ,

$$r_f = \alpha + \beta r_m.$$

The slope of this equation, β , then gives one an approximate measure of the risk associated with an incremental increase in the holding of the f firm's shares in a diversified portfolio. Since the theory suggests a linear relationship between realized rates of returns in each period and the degree of portfolio risk, β , we can substitute the calculated measures of β directly into the mcf equation, rather than constructing stepwise risk classes to get at the rate of return-risk tradeoff curve as we did in the variance cases.¹³ Ceteris paribus we predict a negative relationship between this β variable and investment as our second test of the stockholder welfare maximization model.

To construct the β 's for each firm, we regressed annual rates of return (based on year-end stock prices and dividends) on the annual return for the Standard and Poor's composite 500 average over successive seven-year intervals.¹⁴ The β_t measure used in the empirical

¹² Of course, the rate of return is influenced by general economy-wide factors and shifts cyclically over time. However, since we primarily deal with a cross-sectional analysis here, it is the rate of return relative to that of other firms which is most important for the current analysis. The above measure should capture this component.

¹³ Recent work of Friend and Blume (1970) suggests that the relationship between the *realized* rates of return and β had a systematic nonlinear character over most of this period, exhibiting a declining slope with increasing risk. For this reason we included nonlinear terms in β in our formulation. These exhibited signs consistent with the finding of Friend and Blume but were not statistically significant in any of the models.

¹⁴ The rates of return for both variables were computed using end of year prices and annual dividend payments, rather than market highs and lows as with r_1 . Since we wanted to have a measure of the covariance between the

¹¹ This somewhat unusual assumption on the shareholders entry and exit price was made to get at the *maximum* risk that owning a particular stock could impart to a shareholder. We also computed a measure based on entry and exit at the annual mid-point prices for the stock, but the alternative measure based on high-low sequence always performed better in the regressions (from the standpoint of the neo-classical theory). Hence, we used the latter measure.

analysis is the one obtained from the regression based on the immediately preceding seven-year period. It was felt that seven years provided a long enough interval to capture the relevant historical information relating to the market's current evaluation of a firm's future returns.

Our simultaneous equation system for the stockholder variant of the model can now be fully specified.

$$\begin{aligned}\frac{R_t}{S_t} &= V_0 + V_1 \frac{I_t}{S_t} + V_2 \left(\frac{P}{W} \right)_t + V_3 r_t + \mu'_{Rt} \\ \frac{I_t}{S_t} &= W_0 + W_1 \frac{R_t}{S_t} + W_2 \frac{\Delta S_t}{S_t} \\ &\quad + W_3 \frac{\Delta S_{t-1}}{S_t} + W_4 \frac{\Delta S_{t-2}}{S_t} + W_5 \frac{P_t}{S_t} \\ &\quad + W_6 \frac{DP_{t-1}}{S_t} + W_7 r_t + \mu'_{It}\end{aligned}$$

with $V_2, W_2, W_3, W_4, W_5, W_6, > 0$
 $V_3, W_7 < 0$

where r_t is the neoclassical cost of capital under the variance or covariance method of calculation.

IV The Nature of the Data Samples and Analysis

Both simultaneous equation systems are estimated on data spanning the eight-year period 1959–1966, for 66 firms from seven separate industries — chemicals, drugs, petroleum refining, paper, agricultural and construction machinery, machine tools and ferrous metals.¹⁵ The basis of this sample is a questionnaire survey in which R and D data corresponding to the National Science Foundation definition were solicited from approximately 120 firms in ten separate industries. The industries selected for this questionnaire survey were those for which R and D was primarily company financed. Within each industry data were solicited from the top dozen or so firms ranked by sales. The industries in the current group represent those for which at least a 75 per cent response rate was achieved, thereby giving a representative sample of the large R and D performers in the industry. The 66 firms in the

sample account for roughly one-third of all company financed R and D in the country.

These data can be used in a number of ways to analyze the models presented above. It is, therefore, worth discussing some methodological considerations before proceeding to the empirical work.

In the present formulation, we obtain “desired” or “target” values of the three decision variables by equating their respective *mrr*'s to the mcf function. If a cross-sectional analysis is employed, deviations from ultimate equilibrium values are likely to be a minor component of the overall variation. The model can be estimated in its present form and the coefficients interpreted as estimates of the long run parameters (Kuh, 1963, p. 182). On the other hand, if we were to adopt a time-series approach, the adjustment mechanism to the desired values would become a central component of the period-to-period variations in the observations. In a time-series analysis, therefore, further specification of a dynamic adjustment process — preferably also simultaneously determined — would be required. Rather than further complicate the model at this stage, we instead focus on the cross-sectional component of variation that corresponds best to the equilibrium values specified by our analysis.

On the basis of these considerations one might choose to estimate annual cross sections from our 66-firm sample, perhaps allowing for interindustry effects by means of dummy variables. However, a number of advantages can be obtained by pooling all the data into one grand sample, and then taking deviations around industry-year means. This procedure is equivalent to dealing with the variation which remains after performing a regression on 56 industry-year dummies (7 industries times 8 years) and then using the remaining residual variance to estimate the parameters of the model. In effect, it “sweeps out” the time series and inter-industry component and leaves only the intra-industry component of variation for which the present formulation appears most applicable. Compared to the annual cross-section approach, this technique results in both a substantial increase in the number of degrees of freedom available and a reduction in the instability of the parameter estimates that arise

firm and market returns, we wished to use prices that are synchronized in time, and a high-low measure would not have this property.

¹⁵ R and D data were not available for all eight years for some of the firms. In addition, we omitted some observations because of large scale mergers. In all, a total of 441 observations were available.

TABLE 1. — ESTIMATION OF THE MANAGERIAL VARIANT OF THE MODEL
(TSLS estimators with all variables computed as deviations from industry-year means)

Dependent Variable	$\frac{R_t}{S_t}$	$\frac{I_t}{S_t}$	$\frac{D_t}{S_t}$	$\left(\frac{P}{W}\right)_t$	MC_t	$\frac{\Delta S_t}{S_t}$	$\frac{\Delta S_{t-1}}{S_t}$	$\frac{\Delta S_{t-2}}{S_t}$	$\frac{P_t}{S_t}$	g	σ_r	$\frac{DP_{t-1}}{S_t}$	$\frac{\pi_{t-1}}{S_t}$	$\bar{R}^2/F$
$\frac{R_t}{S_t}$		-.087 (1.69)	-.023 (0.28)	.011 (2.21) ^a	.007 (2.63) ^b							.202 (3.63) ^b	.245 (3.50) ^b	.37/45.11
$\frac{I_t}{S_t}$	-.462 (0.59)		-.217 (0.45)			.111 (3.85) ^b	.039 (1.49)	.031 (1.07)	.017 (0.29)			+.916 (5.57) ^b	.417 (1.22)	.26/17.86
$\frac{D_t}{S_t}$	-.552 (2.39)	-.132 (1.15)								-.081 (3.72) ^b	.479 (3.55) ^b	.000 (.000)	.870 (13.83) ^b	.62/125.3

Notes: Total number of observations — 441.

Numbers in parentheses are *t* values.

^a Significance at 5 per cent level for a two-tailed test.

^b Significance at 1 per cent level for a two-tailed test.

(If standard *t* tests are applied — small sample properties in a simultaneous equational system are not known.)

from year-to-year cyclic variations in the data.

Two-stage least squares is used to estimate the model. There are, of course, well-known difficulties in interpreting the results of all simultaneous equation estimators because of the lack of knowledge about their small sample properties. Nevertheless, we calculate and report the *t*, *R*, and *F* statistics in all cases and treat them as useful information bearing on the validity of the hypotheses incorporated in our model. Partial justification for this is provided by John Cragg's work with Monte Carlo experiments on various simultaneous equation techniques (Cragg, 1964).

V The Empirical Results

A. The Managerial Goals Maximization Model

Table 1 represents the coefficient estimates for the managerial model using TSLS and computing all variables as deviations from the appropriate industry-year means. Considering first the interdependence between the endogenous variables, all six coefficients take on a negative sign. This implies that substitutive interactions are outweighing any complementarity between these variables. Thus, factors positively influencing the return to one of these codetermined variables will ultimately have a negative effect on the other two. However, since only one of these coefficients has a *t* value above 2, many of these substitutive effects may not be very pronounced in character.

Turning to a consideration of the exogenous variables, their performance on the basis of correspondence to expected sign is excellent with all the coefficients exhibiting the predicted sign. Moreover 10 of the 14 coefficients are statistically significant at the 5 per cent level

or better. While it is not surprising that the variables take on the expected signs, since most have been successfully employed elsewhere in single equation studies, it is reassuring that they can be incorporated directly into this simultaneous framework and not exhibit any unusual properties.

For the *R* and *D* equation, the most significant of the exogenous factors are the two cash flow terms. Their coefficients are quite similar in magnitude and possess almost identical and highly significant *t* values. On the other hand, the patent per worker variable, reflecting the productivity of past *R* and *D*, and the percentage of managers on the board of directors, have somewhat smaller, but nevertheless significant *t* statistics. In their present form, both of these variables introduced via the *mrr_R* side have some measurement problems and are at best proxies for factors which are not easily put into quantifiable form. Nevertheless, their significance in the present situation is encouraging and the performance of the management control variable in particular provides a separate strand of support for the managerial model.

For the capital investment equation, the exogenous variables exhibiting the best performance are the unlagged accelerator term, indexing demand pull effects, and the level of depreciation which was included both as a measure of replacement need and as a component of cash flow. Both are highly significant. The two lagged accelerator terms and profits take on the postulated signs with *t* values above 1.0, but not at statistically significant levels (5 per cent test). The lagged patents variable has the worst performance with a *t* value well below 1.0.

The investment equation, while highly significant, exhibits the poorest explanatory power of the above system with an $\bar{R}^2$ of 0.26. This relatively weak performance can be attributed to two factors. First, since capital investment is more sensitive to business cycle and other volatile factors than the other variables, the adjustment process may be quite important even in a cross-section analysis. That is, the variation between actual and desired levels for each firm may not be insignificant compared to the cross-section variation in desired levels across firms. Thus, the specification of a dynamic adjustment mechanism could significantly reduce the amount of unexplained variance observed here. Second, the intra-industry component of variation for variables, such as the accelerator and cash flow terms, might be viewed as less "permanent" than their corresponding inter-industry component. Eisner has made such an interpretation and showed that the explanatory power of the accelerator variables, in particular, improves when performing an inter-industry analysis in comparison to an intra-industry approach (Eisner, 1967).

The dividend equation has the highest F and $\bar{R}^2$ statistics of the three equations. The profit component of cash flow has a very dramatic impact with a t value of 13.8. The strong showing of profit is in accordance with Lintner's basic finding regarding dividend payments of individual firms over time. The very high t value also tends to suggest that over a cross section of similar firms, payout ratios tend to converge somewhat to a common value in accordance with his hypothesis of an imitative reaction among rivals in their long-run payout policies. On the other hand, depreciation has little explanatory power. Since profits are the most visible cash flow element to the shareholders, one can interpret these results as indicating that managers only use this more commonly followed component to arrive at dividends and essentially keep the "hidden" depreciation charges to finance investments. The latter does perform strongly in both the R and D and investment equations.

The two variables introduced via the mrr_D equation, the g and σ_r variables, are also highly significant. The observed results for these variables imply the higher growth in earnings

per share, *ceteris paribus*, the lower dividend payouts will be, whereas the greater the variability in earnings to net worth of the firm, the greater dividend payouts. These results correspond to the predictions for the managerial model. Dividends are paid essentially to obtain security from takeover and similar external pressures, and any factors which diminish this likelihood, like vigorous growth in earnings per share, diminish dividends, whereas factors like high instability of earnings increase the takeover threat and thereby produce higher dividends.

The coupling of dividends with these exogenous factors in precisely the manner predicted by the managerial theory lends considerable support to this theory of motivation. The result concerning the earnings variability coefficient, in particular, is quite inconsistent with a stockholder welfare theory where, if anything, the opposite sign might be expected.¹⁶

B) *The Stockholder Welfare Maximization Model*

Table 2 presents the corresponding estimates of the stockholder welfare model using TSLS with all variables computed as deviations around the appropriate industry-year mean. The first half of table 2 gives the estimates for the system in which the stockholder opportunity cost variable is based on a variance concept of risk, whereas the lower half presents the corresponding results using the covariance related concept. In the two R and D equations, the cost of capital variables perform in accordance with the predictions of the stockholder welfare model, both being negative and significant. However, in the capital investment equations — the reverse is true with their signs being positive in both instances (significant in the case of r_1). Therefore, at best, the estimates on these vari-

¹⁶ In the perfect capital market case, no particular relation between these variables need be expected. On the other hand, with imperfect capital markets a *negative* relation between dividends and earnings reflecting a substitution effect away from external to internal sources because of an increased risk of insolvency associated with the increased earnings variability, would be predicted by the stockholder welfare theory. Such an effect also can exist for the managerially-oriented firm. However, the observed positive sign on σ_r suggests that the fear of takeover from dissident shareholders is outweighing any fear of loss of control through insolvency. This is the prediction in Marris's formulation of the managerial model (Marris, 1964).

TABLE 2. — ESTIMATION OF THE STOCKHOLDER WELFARE VARIANT OF THE MODEL
(TSLS estimators with all variables computed as deviations from industry-year means)

Dependent Variable	$\frac{R_t}{S_t}$	$\frac{I_t}{S_t}$	$\left(\frac{P}{W}\right)_t$	$\frac{\Delta S_t}{S_t}$	$\frac{\Delta S_{t-1}}{S_t}$	$\frac{\Delta S_{t-2}}{S_t}$	$\frac{P_t}{S_t}$	$\frac{DP}{S_t}$	r_1	β_t	R^2/F
$\frac{R_t}{S_t}$		.095 (3.13) ^b	.023 (3.80)						-.227 (4.79) ^b		.025/5.90
$\frac{I_t}{S_t}$	1.15 (0.63)			.110 (3.27) ^b	.052 (2.01) ^a	.053 (2.00) ^a	-.065 (0.56)	.899 (5.04) ^b	.610 (1.74)		.17/13.6
$\frac{R_t}{S_t}$		.103 (2.33) ^a	.013 (2.19) ^a							-.0032 (2.33) ^a	≈0/≈0
$\frac{I_t}{S_t}$	-3.24 (0.30)			.101 (3.26) ^b	.051 (2.06) ^a	.052 (2.04) ^a	.034 (0.52)	.065 (6.43) ^b		.0019 (0.39)	.23/18.7

Notes: See table 1.

ables give mixed support for a stockholder welfare model.

All the other exogenous variables for the stockholder welfare model, with the exception of the sum of patents, take on the postulated signs and many are significant. However, with the omission of cash flow terms, dividends, the dividend related exogenous variables (σ_r and g), and the management control variable, a drastic decline in the $\bar{R}^2$ values for the stockholder welfare model occurs. Compared to the $\bar{R}^2$ of 0.37 in the managerial model, the R and D equations in table 2 have $\bar{R}^2$'s of 0.025 and a slightly negative value.¹⁷ The investment equations exhibit a less dramatic decrease in $\bar{R}^2$, but a decrease nonetheless.

By relaxing some of the assumptions of the strict neoclassical stockholder welfare model, one could reintroduce some of the variables present in the managerial model and narrow the differences in performance between the two. Capital market imperfections could be hypothesized to justify including profits and depreciation. Profits could be included as a measure of expectations. A stockholder preference for some dividends over capital gains would rationalize introducing a dividends equation, and so on. All of these 'real world' modifications should improve the performance of the stockholder welfare model by moving it closer to the managerial version. We have no objections in principle to attempting to rationalize

the stockholder welfare hypothesis by making these modifications. Indeed, it is precisely such real world considerations as the separation of ownership and control, the resulting managerial discretion, and its likely effect on investment behavior, that causes us to develop this managerial model of the firm.

The behavior of two variables in the managerial model cannot be reconciled with a stockholder welfare approach, no matter how liberal the formulation. The significant positive effects of earnings variability on dividends (see footnote 16) and the management control index on R and D are in clear conflict with the stockholder welfare theory. Thus, in the two extreme instances where the theories unquestionably diverge, the results favor the managerial theory. This suggests that the strong performance of the cash flow terms is probably not just an indication of capital market imperfections, but a reflection of the effects of managerial discretionary behavior.

The interpretation of our findings as support for the managerial approach receives considerable reinforcement from a recent study by Baumol, et al., investigating the returns to alternative sources of finance for investment expenditures (Baumol, Heim, Malkiel and Quandt, 1970). Using a multiple regression analysis, they find a significantly lower return on internally generated funds (3.0 to 4.6 per cent) in comparison to that for external funds (4.2 to 14 per cent for debt financing and 14.5 to 20.8 on equity capital). Their samples are quite large and the findings quite robust to alternative specifications. Discrepancies of this magnitude are difficult to rationalize by a hypothesis that managers are maximizing stockholder objectives, even if there are capital mar-

¹⁷ Since the $\bar{R}^2$ for TSLS estimation is computed after substituting the actual values of the jointly determined endogenous variables for the corresponding instrumental values used in the second stage, the $\bar{R}^2$ statistics are not constrained to be positive. A negative $\bar{R}^2$ indicates that the estimated equation is inferior, in terms of the percentage variation explained, to a set of equation estimates equal to the appropriate dependent variable mean values.

ket imperfections. Rather, these results seem best explained in accordance with a managerial model like that employed here, i.e., the lower returns on internal funds result from the conscious policies of managers that have considerable discretionary power over their cash flow and use this power to pursue objectives like growth beyond the point beneficial to shareholders.¹⁸

In summation, the managerial model is statistically superior to a neoclassical version of the stockholder welfare approach. Moreover, the results for the managerial model exhibit a strong pattern of overall consistency which cannot be fully rationalized even in terms of a less extreme formulation of the stockholder welfare model. Coupled with evidence from other sources, these results provide a considerable measure of support for a managerial theory of motivation.

C) *Reduced Form Equivalents of the Model*

Table 3a presents the directional effects of the exogenous variables in the managerial model on R and D, capital investment and dividends as implied by the estimates from table 1, omitting the sum of patents variable because of its low *t* value. These directional effects represent the net impacts of each exogenous variable after allowing for all of the interactions in the model.¹⁹ Thus, they provide the most useful information for the policy maker interested in affecting any of the three decision variables (Mueller, 1967, pp. 81–84).

In addition the estimated impact multipliers of table 3a can be used to provide another test of the validity and consistency of our simultaneous equation approach. This can be accomplished by comparing the derived reduced form with one estimated directly using ordinary

least squares. If the present approach is appropriate, a substantial number of variables entering a reduced form equation from the other two equations in the system should be of the postulated signs and as a group they should provide a statistically significant increment in explanatory power. The statistical performance of the simultaneous model was not of a high enough quality to expect *all* of the variables to perform as predicted, however.

Table 3b presents the signs and *t* value ranges for the reduced form estimated by direct least squares, again employing deviations around industry-year means. One may note first that all the exogenous variables directly influencing the return to a particular activity have the correct sign and are significant. Likewise, the cost of capital variables in each equation exhibit this property.

Of the 13 coefficients associated with variables introduced into the reduced form equations because they affect the returns to a substitute decision, four have *t* values above 2.0 and another five have *t* values above 1.0. Of these nine coefficients, seven have the sign postulated in table 3a. Thus, several of the exogenous variables introduced from other equations are significant or near significant and consistent with the predictions of table 3a based on our simultaneous equation estimates. While the performance of these variables as a group is not statistically overwhelming, they do provide additional support for the hypothesis of substitutive interactions as predicted from the structural estimates.

The current analysis underscores our previous point about the desirability of first specifying and estimating the full simultaneous equation system rather than proceeding directly to the reduced form. From a hypothesis testing standpoint, it is easier to make accurate predictions about the signs of the coefficients of the structural variant of the simultaneous equation model and the resulting estimates are less plagued by the statistical problem of multicollinearity.²⁰ Moreover, by obtaining the reduced

¹⁸ The low estimates of output/capital elasticities obtained by Jorgenson and Siebert (1968) are also consistent with a growth-oriented managerial theory.

¹⁹ Since all the interactions between the endogenous variables are negative (i.e., substitutive relationships) the impact coefficients have a straightforward interpretation. The only variable for which relative magnitudes are important is depreciation, which influences the dependent variable both through the mrr and mcf equations. The calculated signs are positive in the investment and R and D equations (the cash flow effect of depreciation dominating in the latter), and negative in the dividends equation where the non-existent direct cash flow effect of depreciation is swamped by its replacement pull on investment.

²⁰ In general, multicollinearity is a more severe problem in estimating the reduced form, because every exogenous variable is present in all three equations. This factor may be influencing some of the reduced form estimates since significant, although not excessively high, correlations exist between many of the independent variables.

TABLES 3a AND 3b. — DIRECTIONAL IMPACTS ASSOCIATED WITH THE MANAGERIAL MODEL
AS DERIVED FROM THE SIMULTANEOUS EQUATION ESTIMATES (TABLE 3a) AND FROM
ESTIMATION DIRECTLY BY ORDINARY LEAST SQUARES (TABLE 3b)

Dependent Variable	$\left(\frac{P}{W}\right)_t$	MC_t	$\frac{\Delta S_t}{S_t}$	$\frac{\Delta S_{t-1}}{S_t}$	$\frac{\Delta S_{t-2}}{S_t}$	g	σ_s	$\frac{DP_{t-1}}{S_t}$	$\frac{\pi_{t-1}}{S_t}$
$\frac{R_t}{S_t}$	+	+	—	—	—	+	—	+	+
$\frac{I_t}{S_t}$	—	—	+	+	+	+	—	+	+
$\frac{D_t}{S_t}$	—	—	—	—	—	—	+	—	+

Dependent Variable	$\left(\frac{P}{W}\right)_t$	MC_t	$\frac{\Delta S_t}{S_t}$	$\frac{\Delta S_{t-1}}{S_t}$	$\frac{\Delta S_{t-2}}{S_t}$	g	σ_s	$\frac{DP_{t-1}}{S_t}$	$\frac{\pi_{t-1}}{S_t}$
$\frac{R_t}{S_t}$	+	+	+	—	—	—	+	+	+
$\frac{I_t}{S_t}$	(a)	(a)	(c)	(b)	(a)	(a)	(b)	(a)	(a)
$\frac{D_t}{S_t}$	+	—	+	+	+	—	—	+	+
	(c)	(b)	(a)	(a)	(a)	(b)	(a)	(a)	(a)
$\frac{D_t}{S_t}$	—	—	+	—	—	—	+	—	+
	(b)	(c)	(c)	(b)	(a)	(a)	(a)	(a)	(a)

Notes: (a) t value greater than 2.0.
(b) t value greater than 1.0, but less than 2.0.
(c) t value less than 1.0.

form coefficients both directly and indirectly from the structural estimates, one has a further check on the consistency of the model.

VI Summary and Conclusions

We may briefly review our findings in terms of our two initially stated objectives. First, the current simultaneous equation approach demonstrates the basic interdependence between decision variables that can be postulated on theoretical grounds, whatever the motives of the firm's decision-makers. For the most part, the results tend to substantiate the findings of single equation studies of these decision variables. However, they suggest a set of interactions often overlooked in such work. From a policy standpoint, a recognition of these interactions is clearly important in formulating and assessing measures to influence firm expenditure behavior.

The second basic conclusion emerging concerns the motives of corporate managers. The managerial variant of our model has proved both conceptually and statistically superior to the pure stockholder welfare maximization version. Its theoretical advantage derives from its much broader scope which allows stockholder welfare to be one of the factors affecting investment and dividends decisions, but also provides for the impact of variables that are solely related to managerial welfare. We feel

that investigations of the kind presented here, that explicitly derive the relationships between the dividends and investment decisions one expects under different motivational assumptions, and then test and compare these predictions, provide one of the most promising means of discriminating between modern and more traditional theories of the firm. Further analysis along these lines, perhaps expanded to include other investment decisions, like advertising and mergers, should provide important insights into this central issue of micro-economics.

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