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Chapter Four

Capital Expenditures—The Basic Model

ANALYTICAL FOUNDATIONS AND COMPLICATIONS

Prospectus

Our analysis of capital expenditure functions begins with an updating of previous work on a basic accelerator-profits model. Capital expenditures are taken as a freely estimated distributed lag function of past changes in sales, profits, and depreciation charges. In pointing out differences in estimates from various time series and cross sectional structuring of the data, we shall bring into sharper focus a "permanent income theory" for investment. This relates, on an empirical plane, largely to underlying differences in the relations between current and past variables and expectations of the future. That, in turn, will bring us to an analysis of the role of explicitly reported sales expectations, the utilization of capacity, and other variables, including the market value of the firm, which may act as proxies for the relevant future.

Next (in Chapter 5) come a number of further topics on most of which we have not published findings before. These include new analyses of asymmetrical accelerator relations in which capital expenditures are permitted to react differently to rising and to falling sales, and some further consideration of the role of profits. The imperfection of capital markets suggests that available profits may produce a speedier reaction to demand-induced capital expenditures, particularly in response to rising sales, and may have an accentuated role in smaller firms, where access to outside funds is more limited.

Some Problems

"Always study your residuals," Paul Samuelson (1965) advised the scientific forecaster. But the econometrician working in the field of investment might well exclaim, "*Which* residuals?" For, indeed, the first question is which relation to estimate. And immediately following it is the question of what measured variables to take as proxies for the variables of our theoretical relation.

At the root of the difficulty is the fact that investment, even more than other behavior, is forward looking, dependent upon a relation between initial conditions that we may know, more or less, and expectations of the future about which both the investment decision-maker himself and his trailing econometrician are frequently singularly ill-informed. Some of the vagaries of the relations among past and expected future sales changes were noted in Chapter 2. And the list of variables in our econometric models for the investment relation seems endless. It includes items such as current and past output, sales, profits, stock yields, interest rates, depreciation charges, stock of capital, age of capital, capacity, prices of output, prices of labor and of capital goods, "liquidity," a host of tax parameters, composite variables measuring "cost of capital" and "rental price of capital," a great variety of lags, many dummy variables relating to specific factors, behavioral units, subaggregates or time periods, and some measures of expectations.

Investment functions have been estimated from data at the level of national aggregates, industries, firms, and establishments. Investigators have variously used cross sections and time series, as well as "overall" or hybrid relations involving observations for cross sections of units such as firms or industries over different time periods.

On the surface, the underlying theory from which one might hope to derive an estimating relation would not seem all that difficult. Essentially, we think of firms trying to maximize their present values, given a set of capitalization rates of expected future returns and given a set of initial conditions that conspicuously includes the existing stock of capital. With output constrained by a production function, investment is derived directly from the solution path for capital stock, taking into account the depreciation or wearing out of capital implied by the solution output and composition and amounts of capital called for by the production function.

Complications begin to develop rapidly, however. Imperfect competition forces the etching in of so many extra lines on this broad canvas that the picture becomes almost unrecognizable. For one thing, for sets of expected future prices we must now substitute sets of expected future demand curves with possibly varying elasticities over time and even with elasticities subject to control or influence by the firms themselves. The downward sloping demand curves at least have the virtue of enabling our investment theory to introduce demand considerations (as opposed to purely price parameters) at the level of the individual firm as well as of the industry or the economy as a whole. But as we also recognize less than perfect elasticities of supply, we add the seriously complicating, while clearly realistic, dimension of cost of adjustment. The optimum or solution capital stock at any given time will almost certainly be different as we recognize that the costs per unit of all factors of production are related to the rates at which they are being acquired and probably also to the relations between rates of acquisition at various given times.[1]

The rational (and informed) entrepreneur, then, must plan a path for capital over time that maximizes his firm's present value, taking into account not only all of the initial conditions and current parameters—production function, supply and demand functions, and tax structure—but the expected values of these parameters over all of the relevant future. What is worse, each decisionmaker is in the usual oligopolistic quandary, attempting to estimate his optimal moves in full recognition that these depend upon the responses of other firms to the moves that he makes or that the other firms expect him to make. And perhaps complicating matters still further, it is not entirely reasonable to assume that firms in a world of risk and uncertainty act in a manner designed to maximize their present values. Rather, they may wish to maximize a function in which the mathematical expectation of present values enters positively while the variance of the probability distribution of anticipated present value outcomes enters negatively. Indeed, in a world of uncertainty and imperfect information, decisions maximizing current market value may not be rational for entrepreneurs interested in maximizing some function of wealth over time. An entrepreneur may wisely decide upon an investment path that he is confident will raise the value of his firm in the future by reducing risk and hence lowering capitalization rates or otherwise favorably affecting the value of the firm in ways not currently anticipated by the market.

These complications may begin to reveal the difficulty of our task. Operating at the level of the individual firm, where can we even begin to get information on the relevant variables? We have hardly any notion of the production function or the demand and supply

[1] See Eisner and Strotz (1963), Nadiri and Rosen (1969 and 1973), Coen and Hickman (1970), Nadiri (1972), and a burgeoning theoretical literature on this subject.

functions of the past or present, let alone those anticipated for the future. This information is barely available to the business decision-maker himself and then only in a scattered or desultory form, which may prove operationally meaningful to him, but is scarcely the stuff for our own consistent quantification.

What then do we do? We simplify! Now, while simplification is of the essence in scientific procedure, it is important that it preserve the essentials of the relationship with which we are concerned, and it is not at all clear that this is so in much of our work with investment. For the first, overwhelming simplification involves substituting past or current variables for the anticipated future variables that are relevant. We are bound by the availability of data; we simply do not know what demand, supply, relative prices, production functions, and tax structures will be in the future or even precisely what economic behavioral units expect them to be. And then, since we hardly have reliable information on any of the functions we have been talking about, we usually deal with observations, for the past and present, of points on these functions. Thus, we find ourselves dealing not with demand functions but with past sales, not with supply functions but with current and past rates of factor acquisition.

There are methods for rationalizing this. One could argue, for example, that shifts in demand are expected to be isoelastic and marginal costs constant, so that prices of output will remain unchanged. It could then be assumed that expected future output will be some given or estimable function of past and current sales or output. We might assume that the elasticity of all price expectations is unity, meaning that all changes in current prices, or some weighted average of current and past prices, will be reflected in proportionate changes in expected future prices.

In some cases, present variables, because of limitations in the perfection of markets, may actually serve well. If firms' capital costs are determined at the time capital expenditures begin and financing is arranged, part of the issue of expected future prices may be dismissed. But capitalization rates may yet change in the future, altering the present value of expected future returns and affecting the actions of later competitors, whose future investment will then influence the value of investment currently being undertaken.

As to the data at our disposal, a word of warning must be sounded at this juncture. On the one hand, much of the analysis that follows will benefit from the rich and varied nature of the McGraw-Hill individual firm responses over a large number of years. On the other hand, it will be restricted by the relative paucity, if not absence, of data on certain possibly important variables, particularly those dealing with cost of capital and relative price of capital and other factors of production.

A BASIC ACCELERATOR-PROFITS INVESTMENT FUNCTION

Basic theoretical considerations discussed in Chapter 1 suggest that the rate of expected output should be a prime determinant of investment. Given a well-behaved production function in which first derivatives and cross partials are positive and second derivatives negative in the relevant range (marginal products of factors positive but falling and positively related to the amounts of other factors employed), increases in output would require increases in inputs, with cost minimization arguing for increases in all inputs at rates dependent upon the varying and related costs of adjustment. First responses to increases in demand are likely to be increases in sales and output, achieved by increasing inputs of the most variable factors, that is, those with the least costs of adjustment. A priori hypotheses, casual empiricism, and some recent empirical work all suggest that the impact of changes in demand will be felt first in "utilization" of existing capital: changing the hours of employment or labor and then changing the quantity of employment.[2] There may also be some short-run effects upon the rate of scrapping or elimination of existing plant and equipment. As new levels of demand persist and expectations to that effect are reinforced, cost minimization will argue for a movement away from those factors whose marginal products have decreased with increased short-run use and toward those factors, particularly plant and equipment, whose marginal products have increased with the greater short-run use of other factors. Costs of securing information about the future and costs of planning, commitment, and purchase or construction will then dictate the speed at which capital stock adjusts to changes in demand.

If sales are taken as a prime observable measure of demand and frequently of output as well, the stock of capital can be expected to change with changes in sales, and net investment may be taken as a distributed lag function of current and past changes in sales. Gross capital expenditures will also depend upon the need to replace the portions of existing capital becoming worn out or obsolete. A rough measure of this may be found in depreciation charges. Finally, other forces influencing the expected profitability of investment may be captured in current and past profits, which may also pick up certain

[2] See, for example, Nadiri (1972) and Nadiri and Rosen (1973).

capital supply effects. To the extent that capital markets are imperfect, firms tend to invest more when profits are high and less when profits are low.

Our basic relation therefore involves gross capital expenditures as a function of current and past sales changes, current and past profits, and depreciation charges. The capital expenditure data used in this connection were taken directly from the McGraw-Hill surveys, but sales information, although available in these surveys, seemed somewhat more reliable in published accounting form. Thus, sales data, along with those on profits before taxes and depreciation charges, were taken from Moody's.

As noted in Chapter 1, to reduce heteroscedasticity associated with differences in size of firm in cross section analysis, variables were generally normalized by dividing capital expenditures, profits, and depreciation charges by gross fixed assets and by dividing sales changes for each firm by an average of its sales. This normalization in effect gives equal weight to each firm regardless of size. The ratio of capital expenditures to gross fixed assets has the further advantage, to the extent that the depreciation variable can be used in a measure of replacement requirements, of defining the relative growth of capital. The ratio of sales change to average sales enables us to relate the relative growth of capital to the relative growth of sales (and implicitly, in the long run, of output). We hence finesse the interfirm differences in capital-sales or capital-output ratios, which would entail a serious misspecification in multifirm linear regressions relating investment to changes in demand.

While most of the firms in the McGraw-Hill sample are large by any standard, to the extent that the largest firms may differ in behavior from those not quite as large, our estimates of the investment function may be particularly misleading predictors of aggregative behavior. Transformation of variables to the ratio form offers the further possibility of considerable weight to "outliers" that are extreme in transformed values even if not extreme in the variables underlying our presumed structural relations. Hence it was deemed advisable to exclude observations containing extreme values of any of the variables. Upper and lower bounds of acceptable intervals were established on the basis of preliminary analysis of means and standard deviations. Intervals were generally set so that one would expect no more than 1 percent of observations to be excluded because of extreme values on any one variable.

No attempt was made to utilize information from incomplete observation vectors; a considerable number of observations were rejected because of missing information on only one or several variables. The appendix to this chapter describes the variables utilized and indicates the intervals for acceptable values. Each table in the text reports the number of observations rejected because of extreme values of at least one of the variables in the observation vector.

Our first, basic table, 4-1, reports on the results of regressions involving 4,534 observations of capital expenditures of individual firms in ten broad industry groups over the fourteen year period from 1955 to 1968. We have estimated in a "firm overall regression" an assumed linear functional relation between capital expenditures as a ratio of 1957 gross fixed assets and the following independent variables: the ratios of current and six lagged annual sales changes to mean sales for 1956 to 1958, the current and lagged ratios of profits to 1957 gross fixed assets, and the 1953 ratio of depreciation charges to gross fixed assets. As suggested, one might take the sales change variables as a proxy for changes in expected future demand, the depreciation variable as a measure of replacement requirements (or is it flow of funds?), and the profits variables for everything else left out that might affect the expected profitability of investment.

In some ways the results shown in Table 4-1 are encouraging as well as enlightening. As one would expect from good acceleration principles (or from our assumed production function with diminishing marginal products to each factor but positive cross-partial derivatives), the sales change coefficients are all clearly significantly positive and sum to a substantial 0.486, indicating that a 10 percent change in sales (or demand or output?) resulted in a corresponding 5 percent change in capital stock over a six year period. Noting the means of each of the variables, the sales change coefficients imply that the elimination of growth of sales, ceteris paribus, would on average reduce capital expenditures of the firm by some 25 percent. A similar perusal of the other coefficients and means suggests that, with no profits, capital expenditures would be some 15 percent less, while, with no depreciation charges (and replacement requirements?), capital expenditures would be 37 percent less. Finally, we are left with a rather disconcerting significantly positive constant term of 0.022. This argues that, with zero values for all of our independent variables, capital expenditures equal to 2.2 percent of 1957 gross fixed assets—some 23 percent of total capital expenditures—would still be made.

Before going on to additional results, it may be well to reflect a bit on these. First, we have a fairly typical distributed lag investment function, in which there is some prompt response of capital expenditures to change in sales, with a hint of a hump in the second year and

Table 4-1. Capital Expenditures as a Function of Sales Changes, Profits, and Depreciation, Firm Overall Regression, 1955-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + b_{10} d_{53} + u_t$$

(1) *Variable or Statistic*	*(2)* *Regression Coefficients and Standard Errors*	*(3)* *Means and Standard Deviations and Products*
Constant or i_t	.022 (.002)	.096 (.077)
Δs_t	.088 (.008)	.064 (.131)
Δs_{t-1}	.096 (.008)	.054 (.130)
Δs_{t-2}	.082 (.008)	.049 (.129)
Δs_{t-3}	.067 (.008)	.045 (.122)
Δs_{t-4}	.065 (.008)	.044 (.119)
Δs_{t-5}	.054 (.008)	.045 (.118)
Δs_{t-6}	.034 (.008)	.037 (.122)
p_t	−.061 (.024)	.109 (.107)
p_{t-1}	.194 (.025)	.105 (.102)
d_{53}	.678 (.037)	.053 (.028)
$\Sigma\Delta s$ coefficients	.486 (.020)	$\sum_{j=1}^{7} b_j \cdot \text{mean } s_{t+1-j}$ = .024
Σp coefficients	.133 (.010)	$\sum_{j=8}^{9} b_j \cdot \text{mean } p_{t+8-j}$ = .014
$di/d\Delta s$	.559	$b_{10} \cdot \text{mean } d_{53}$ = .036
n (−350)	4534	
r.d.f.	4523	
$\hat{R}^2$	.307	Constant = .022
F	202.0	Total = mean i_t = .096

coefficients trailing off but remaining significantly positive through six annual lagged sales changes. Previous experimentation has shown that the accelerator effect is pretty well dissipated after six years (or seven, including the current year).

While the lag pattern is plausible, the size of the coefficients raises some problems. If one assumes the production function to be homogeneous of the first degree and the relative prices of factors of production to be unchanging, one should expect changes in sales to result eventually in fully proportionate changes in capital stock. This would be true if current and past changes in sales were matched by corresponding changes in expected sales—essentially, if the elasticity of sales expectations were unity. And as our variables have been defined, with capital expenditures measured roughly (aside from price deflation problems) as a ratio of gross fixed assets or capital stock and changes in sales measured as ratios of sales, the sum of the regression coefficients of the sales change variables should equal unity.

Some of the difficulty may well lie in any assumption that the production function is homogeneous of the first degree. In particular, increasing returns to scale or a trend of capital-saving innovation would imply a capital expansion less than proportionate to increases in sales and output. Another hypothesis worth entertaining, in view of our analysis of sales expectations and realizations, is that the elasticity of sales expectations is indeed less than unity. Individual firms may view substantial portions of variations in their own sales as transitory, calling for no revision in expectations of long-term future demand relevant to investment.

The (absolutely) small but negative coefficient of current profits, p_t, may be traced to (1) little stimulatory effect of unlagged profits on investment, plus (2) a negative relation stemming from the higher depreciation charges and possibly startup costs (or other reductions of accounting net income associated with higher capital expenditures). The substantial positive coefficient, 0.194, of lagged profits, as hypothesized earlier, may relate to imperfect capital markets, which cause firms with less than optimal capital stocks to begin investing when profits are higher or available, as well as to other forces that make past profits a proxy for the expected profitability of investment. It may also reflect a role of profits in the speed of investment induced by other factors (such as increases in demand), a role explored later but not directly provided for in this specification.

The full role of the acceleration principle may well be missed, however, by considering only the effect of sales changes, ceteris paribus. In particular, increasing sales usually mean higher profits. Thus, we should trace not only the direct effect of sales changes on investment but their indirect effect via profits.[3] We may formulate this:

$$\frac{di}{d\Delta s} = \frac{\partial i}{\partial \Delta s} + \frac{\partial i}{\partial p} \cdot \frac{dp}{d\Delta s}$$

In fact, this role of increasing sales through profits has substance. The firm overall regression of current profits on current and past sales changes yields a sum of sales change coefficients of 0.667; for lagged profits the corresponding sum is 0.584 (see Tables M4-2 and M4-3). Taking into account our lag structure, we may then measure the total response to sales changes of the investment to gross fixed assets ratio as

$$\frac{di}{d\Delta s} = \sum_{j=1}^{7} \partial i/\partial \Delta s_{t-j} + \sum_{j=1}^{2} (\partial i/\partial p_{t-j})\,(dp_{t-j}/d\Delta s)$$

where the first summation is simply our sales change coefficients in the investment function, and $dp_{t-j}/d\Delta s$, $j = 1, 2$, are the sums of the sales change coefficients for current and lagged profits, respectively.

In connection with the overall regression of Table 4-1, where the sum of sales change coefficients in the investment function was 0.486, we now find that

$$\frac{di}{d\Delta s} = 0.486 - 0.061(0.666) + 0.194(0.584) = 0.559$$

This difference between $di/d\Delta s$ and $\partial i/\partial \Delta s$ is modest, but it proves more substantial in time series regressions, as we shall see below.

The fairly high and positive coefficient, 0.678, of the depreciation charge variable suggests that firms do make gross capital expenditures, presumably for replacement and modernization, equal to a substantial portion of their depreciation charges. Any inference that this implies a cash flow role for depreciation in bringing on capital expenditures does not seem warranted, however. For one thing, if this were a dominant factor, one should expect the coefficients of net profits and depreciation to be similar, as both would be expected to be highly correlated with cash flow. In fact, the sum of the profits coefficients, 0.133, is not quite one-fifth of the depreciation coefficient. Second, the depreciation variable in this regression is a constant for each firm and relates to the year 1953, before the

[3] I am indebted to Paul Wachtel for this suggestion.

succession of liberalizations in tax depreciation policy, frequently alleged to stimulate capital expenditures, was begun. Variance of the depreciation ratio in this relation therefore overwhelmingly reflects differences between firms in the estimated lives of plant and equipment being depreciated by the old straight-line method. Firms with higher depreciation ratios would be firms with mixes of plant and equipment estimated to have shorter lives and hence, on the average, requiring replacement in any given year of larger proportions of existing capital stock.

A PERMANENT INCOME THEORY FOR INVESTMENT

The "overall" regression discussed above is in effect a cross section-time series relation. Each observation differs from every other observation with regard to identity of the firm or the year or both. Variance and covariance involve deviations from the overall mean of observations of all firms in all years and hence relate both to differences in firm, or cross sections, and to differences in year, or time series. Can we expect relations among deviations from means to be the same whether we deal with deviations of each firm from the means of its industry, those of each firm from the mean of all firms, the deviations over time for each firm from its own mean, those of industry means from the overall mean, the deviations for each industry of the mean of firm observations for each year from the mean of that industry's observations for all years, or all the deviations of industry year means or individual firm observations from the overall mean?

My own exploration of the varying estimates that might be expected from different structurings of data began with confirmation of a hypothesis by Friedman (1957) that, if cross sections of households were subdivided into groups relatively homogeneous in permanent income, transitory components were likely to dominate the intragroup variances and bias downward the estimates of slope and elasticity of the consumption-income relation. I further observed that, when the group means were taken as observations, slopes and elasticities were both higher than those calculated from the cross sections of individual households, and consumption was indeed estimated to be an almost homogeneous (linear) function of income (Eisner, 1958b).

It is reasonable to expect the same phenomena in estimates of the investment function. Again, bygones must be bygones. This is true, after all, regardless of the variables that we consider significant for investment. Neither output (or sales) nor earnings, rates of interest, or technological change should affect the current or future rates of investment except insofar as they affect initial conditions or expectations of relevant future variables. Initial conditions may, of course, include the existing capital stock and state of technology and finances determined by past variables. They may even include an immediately past rate of investment that can only be changed rapidly at considerable cost. But it is still the initial conditions and expected future paths of variables to which the investment function must relate. Estimates of the investment function that use past values of variables as observations will be as meaningful and stable as the relations among those past variables and the true arguments of the investment function.

A prime determinant of capital expenditures must be changes in expected future demand or the relation between expected future demand and existing capacity. A sophisticated or flexible application of the acceleration principle, by which the rate of investment demand depends upon the acceleration of the rate of the demand for output, will reflect this underlying relation between expected demand and capacity to the extent that it measures variations in past demand that are not merely bygones but that may be viewed by business decisionmakers as permanent. Thus, one could expect little relation between current investment and the current rate of change of output or that prevailing over a short preceding period of time. One should, however, expect to find a much more substantial relation between current capital expenditures and measures of the rates of change in demand over a considerable number of past periods.

Further, estimates of the investment function based upon the covariance of capital expenditures and measures of changes in demand will indicate higher coefficients of demand variables where the variance and covariance relate more to permanent components of demand.

It should be possible to confirm this hypothesis by comparing estimates of the relation between investment and previous changes in sales on an intraindustry, interfirm basis with similar estimates on an interindustry year basis. With the assumption that average changes in sales of all of the firms in an industry in a given year would prove a better proxy for future demands relative to investment than would the sales experience of an individual firm, the industry year regression should yield the highest sales change or "accelerator" coefficients. The hypothesis could also be evaluated by means of comparisons of cross section and time series regressions from the same underlying set of data. For again, as noted in our earlier analysis of sales expectations, variation in experience over time, particularly on the part of individual firms, is likely to be viewed as more transitory than cross-sectional differences among firms and, a fortiori, among industries.

It will be our purpose not only to offer empirical evidence for caution in interpreting any particular set of estimates by noting the differences among them, but also to suggest and test the role of a permanent income hypothesis in explaining the differences. At least with regard to demand variables, one should expect variation over time in the experience of an individual firm to have the smallest relative permanent component. Since investment must be undertaken on the basis of expected profitability over long periods of time, firms may be expected to be cautious in altering their rates of investment in response to relatively short-term fluctuations in demand. By utilizing a distributed lag function, estimating separately and without constraint the coefficients of individual lagged variables, we may expect to pick up some longer run effect, but we should still look for the role of demand variables to be obscured significantly in firm time series.

Turning to liquidity variables, a priori reasoning is somewhat less certain. If imperfections in capital markets (perhaps particularly for small firms) tie financing to current or past profits, capital expenditures may proceed at a more rapid rate when the flow of profits has been more rapid.

We might also expect a relatively reduced role for demand variables in cross sections of the firms within each industry, although possibly a greater one than in the firm time series discussed above. For here we may argue that business decisionmakers are unlikely to view the difference between their own firm's experience in a given year and that of their industry as clearly indicative of differences in long-run expectations that should affect capital expenditures. The force of this argument is somewhat weakened by the fact that our "industries" are quite large industry groups sufficiently heterogeneous in character to encompass a wide variety of experience.

Regressions of industry time series should perhaps show a stronger role for demand than those of firm time series. This role may still be restricted, however, by the probability that much of the interyear, intraindustry variance in demand over the years under study was likely to be viewed as transitory. One should clearly expect estimates suggesting a greater role for demand variables in longer time series that include great long-run variations in demand.

The role of past demand should show up most clearly in interindustry cross sections. At the firm level this may become apparent in cross sections across industries, but permanent effects may be partially obscured by the "noise" or errors in variables of individual year observations. Year-to-year transitory fluctuations should, however, tend to wash out in cross sections of firm means, which would capture more of the longer run differences among firms. And similarly, to the extent that demand has been growing more rapidly in one industry than in others, firms within that more rapidly growing industry are more likely to have favorable long-term demand expectations than firms whose growth in demand happens to have been larger than the mean of their average growth industry. Business thinking, on what may appear to be an unsophisticated level to the scientific observer, runs frequently in terms of accustomed "shares of the market." This, however, may actually be a reflection of the statistical law of large numbers. The experience of all the firms in a given industry may be a better estimator of future prospects of an individual firm than the single past experience of that firm itself.

Turning now to Table 4-4,[4] we may note first the contrast between results of the cross section of firms across industries and the cross section of firms within industries. By our hypothesis that firms may view differences between their own sales experience and that of other firms within their industry as less permanent than the differences between their own sales experience (or that of their industry) and the experience of all other firms, we should expect the sum of the coefficients of sales changes to be smaller in the case of the within industry regression. And so it is: 0.377 as against 0.405 in the firm cross section across industries. Correspondingly, the sum of coefficients of sales changes in the industry cross section equals 0.452, consistent with our hypothesis that differences between industries would reflect in larger part differences in the permanent component of changes in demand. The within industry profits coefficients are somewhat higher than those across industries, suggesting that firms may invest some of their transitory increases in profits the year after they are received. Corresponding to the somewhat higher coefficients of lagged profits in the regression for individual firms within industries, however, there is a sum of profits coefficients which is insignificantly negative in the industry cross section. Indeed, the difference between the sums of profits coefficients in these latter regressions is 0.206, with a standard error of 0.053, quite significantly different from zero.

Regressions based upon cross sections of firm means reveal higher sales change coefficients and higher coefficients of determination

[4] Tables M4-2 and M4-3 appear only in microfiche.

than do the cross sections of individual firm observations. This would seem to confirm the hypothesis that individual firm variance in sales is partly viewed as transitory and is washed out in averaging. Some reservations may be appropriate for the regressions involving firm means, however, as a relation between mean capital expenditures over a number of years and mean sales changes over a number of years involves components of sales changes which follow in time capital expenditures entering into the capital expenditures mean. There is thus some problem in identifying the underlying relation estimated: Are the sales changes contributing to investment or is investment contributing to future capacity, which, in turn, makes increases in sales possible?

In the industry overall regression, where the coefficient of determination is 0.669, the sum of sales change coefficients is 0.760, and the depreciation coefficient is 0.799. The estimated lag structure suggests a fairly modest immediate response of capital expenditures to sales change, a major hump in the second year, and regularly declining coefficients thereafter.

The sum of sales change coefficients of 0.760, although significantly below unity, is no longer in serious contradiction to notions of a production function with fairly constant returns to scale or to an elasticity of expectations reasonably close to unity. Curiously, this sum of sales change coefficients in the industry overall regression has proved a rising function of the number of years from which the observations have been drawn. In a similar regression reported some years ago for data then available over the period 1955 through 1962, the sum of the sales change coefficients was only 0.544, as seen in Table 4-5. In still later results reported for the years 1955 through 1966, the corresponding sum of sales coefficients was 0.732. Despite the 1955-1968 sum of 0.760, the corresponding figure for the years 1963-1968 was only 0.591. But before the difference is belabored, it must be recognized that standard errors are high and that the F ratios do not indicate a statistically significant difference between the regressions.

There are significant differences in the individual firm cross section and overall regressions between the earlier and later periods, however. These apparently relate to higher profits coefficients later. Those might stem from the effects of accelerated depreciation in reducing the relative variance of the profits variables in the years 1963-1968, but this appears at best to be only a partial explanation.

Turning to the firm time series results in Table 4-6, we note first that the accelerator effect is less marked than in cross section or overall regressions. Although sales change coefficients are positive for

Table 4-4. Capital Expenditures as a Function of Sales Changes, Profits, and Depreciation, Firm and Industry Cross Sections and Industry Overall Regressions, 1955-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + b_{10} d_{53} + u_t$$

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
	Regression Coefficients and Standard Errors					
	Firm Cross Section				*Industry*	
Variable or Statistic	*Within industries*	*Across industries*	*Means within industries*	*Means across industries*	*Cross section*	*Overall*
Constant	.029 (.003)	.024 (.002)	.026 (.006)	.024 (.006)	.019 (.006)	.014 (.006)
Δs_t	.078 (.008)	.077 (.008)	.127 (.055)	.091 (.059)	.016 (.060)	.073 (.053)
Δs_{t-1}	.066 (.008)	.076 (.008)	.074 (.065)	.123 (.069)	.161 (.051)	.212 (.036)
Δs_{t-2}	.060 (.008)	.067 (.008)	.012 (.061)	−.009 (.066)	.111 (.049)	.159 (.032)
Δs_{t-3}	.049 (.009)	.053 (.008)	.149 (.055)	.157 (.059)	.059 (.050)	.130 (.035)
Δs_{t-4}	.048 (.009)	.052 (.009)	.004 (.056)	.007 (.060)	.054 (.049)	.103 (.038)
Δs_{t-5}	.052 (.009)	.052 (.009)	.126 (.061)	.063 (.065)	.022 (.049)	.038 (.040)
Δs_{t-6}	.023 (.009)	.029 (.008)	.057 (.053)	.117 (.056)	.030 (.048)	.045 (.035)
p_t	−.059 (.023)	−.060 (.024)	−.160 (.133)	−.083 (.144)	.163 (.213)	.041 (.193)
p_{t-1}	.204 (.024)	.178 (.025)	.290 (.141)	.175 (.152)	−.223 (.226)	−.021 (.203)
d_{53}	.628 (.043)	.747 (.036)	.567 (.077)	.698 (.068)	1.140 (.142)	.799 (.133)
$\Sigma \Delta s$ Coefficients	.377 (.022)	.405 (.021)	.549 (.051)	.550 (.050)	.452 (.098)	.760 (.081)
Σp Coefficients	.145 (.011)	.118 (.010)	.130 (.022)	.092 (.022)	−.061 (.052)	.020 (.052)
$di/d\Delta s$	.445	.464	.609	.598	.422	.776
n (−350)	4533	4534	533	533	139	139

Table 4-4 continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Firm Cross Section				*Industry*	
Variable or Statistic	*Within industries*	*Across industries*	*Means within industries*	*Means across industries*	*Cross section*	*Overall*
r.d.f.	4385	4510	513	522	115	128
$\hat{R}^2$	.200	.270	.386	.462	.604	.669
F	111.21	168.50	33.83	46.66	20.07	28.87
F[(3) – (2) – (6)] = 7.68; $F_{.01}$ = 2.32.						

Note: Tables M4-2 and M4-3 appear only in microfiche.

each lagged sales change—and quite significantly so for all except the last—the sum of the coefficients of 0.322, while greater than that in shorter time series (0.244 in results reported in Table 4-5 for data from 1955 through 1962), is decidedly less than the corresponding sum of 0.683 in the cross section of firm means. The *F* ratio of 11.05 for the reduction of residual variance confirms the heterogeneity of the regressions; the difference of 0.360 in the sums of coefficients, with a standard error[5] of 0.060, is clearly statistically significant. This result is consistent with the hypothesis that firms would view variations in their own sales experience, particularly over a limited period of time (for most firms the variation was over a shorter period than fourteen years because of missing observations), as permanent to a lesser degree than the differences between their own average sales experience and the average experience of all other firms in the economy. To the extent that variation over time of their own sales experience is part of that of the industry as a whole, it may be viewed in larger part as permanent. Confirmation of this is suggested by the sum of 0.615 for the coefficients of sales changes in the industry time series, larger than the figure for the firm time series and approaching that of the cross section of firm means.

But now, pursuing the role of sales changes via their effect on profits, we find a substantial difference between the total role of sales changes, $di/d\Delta s$, and the partial role, $\partial i/\partial \Delta s$. Reapplying the formulation described above in connection with the firm overall regression of Table 4-1, we find that for the firm time series,

[5] Calculated on the assumption of zero covariance of estimates of the two sets of sums.

Table 4-5. Capital Expenditures as a Function of Sales Changes, Profits, and Depreciation, Firm and Industry Cross Sections and Overall Regressions, 1955-1962 versus 1963-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + b_{10} d_{53} + u_t$$

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
	Regression Coefficiens and Standard Errors							
		Firm Cross Section				*Industry*		
Variable or Statistic	*Firm overall*	*Within industries*	*Across industries*	*Means within industries*	*Means across industries*	*Cross section*	*Overall*	*Means and Standard Deviations*[a]
A. 1955-1962								
$\Sigma\Delta s$ Coefficients	.417 (.027)	.361 (.028)	.410 (.027)	.416 (.053)	.450 (.052)	.533 (.137)	.544 (.130)	.034 (.116)
Σp Coefficients	.053 (.013)	.084 (.013)	.051 (.013)	.072 (.022)	.034 (.022)	−.199 (.075)	−.190 (.072)	.095 (.091)
d_{53}	.763 (.041)	.595 (.048)	.763 (.041)	.588 (.076)	.771 (.068)	1.267 (.176)	1.256 (.168)	.053 (.028)
$n(-184)$ [or i_t]	3147	3147	3147	523	523	80	80	.085 (.068)
r.d.f.	3136	3057	3129	503	512	62	69	
$\hat{R}^2$	.248	.162	.244	.298	.410	.629	.643	
F	104.68	60.42	102.24	22.82	37.28	13.23	15.22	

$F[(4) - (3) - (7)] = 11.91$; $F_{.01} = 2.32$.

B. 1963-1968								
$\Sigma\Delta s$ Coefficients	.443 (.035)	.381 (.039)	.380 (.036)	.495 (.066)	.476 (.062)	.335 (.143)	.591 (.138)	.099 (.129)
Σp Coefficients	.222 (.018)	.237 (.020)	.212 (.018)	.231 (.034)	.215 (.031)	.105 (.070)	.178 (.074)	.126 (.118)
d_{53}	.696 (.077)	.783 (.092)	.754 (.076)	.713 (.140)	.697 (.116)	.976 (.267)	.599 (.281)	.051 (.027)
$n(-166)$ [or i_t]	1387	1386	1387	322	322	59	59	.122 (.086)
r.d.f.	1376	1318	1371	302	311	43	48	
$\hat{R}^2$	.361	.280	.336	.401	.463	.602	.626	
F	79.17	52.76	70.98	21.88	28.65	9.02	10.71	
	F[(4) – (3) – (7)] = 1.31; $F_{.01}$ = 2.32; $F_{.1}$ = 1.60.							
F[(55-68) – (55-62) – (63-68)][b]	15.97	8.15	8.47	7.39	15.31	1.18	1.81	
$F_{.01}$	2.25	2.32	2.32	1.90	2.27	2.49	2.40	

[a]Standard deviations from firm cross section across industries; means are for Δs_{t-1}, p_{t-1}, d_{53}, and i_t, respectively.

[b]For reduction in residual variance, adjusting for number of observations where necessary, from 1955-1968 regressions.

Table 4-6. Capital Expenditures as a Function of Sales Changes and Profits, Firm and Industry Time Series and Cross Sections, and Firm Overall Regressions, 1955-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + u_t$$

(1) Variable or Statistic	(2) Firm Time Series	(3) Cross Section of Firm Means	(4) Firm Overall	(5) Cross Section of Means within Industries	(6) Industry Time Series	(7) Firm Cross Section within Industries	(8) Industry Cross Section	(9) Firm Cross Section across Industries
Constant	.044 (.002)	.047 (.006)	.050 (.002)	.049 (.006)	.022 (.007)	.057 (.002)	.041 (.007)	.054 (.002)
Δs_t	.068 (.008)	.150 (.064)	.094 (.009)	.144 (.058)	.049 (.038)	.082 (.009)	.085 (.074)	.088 (.009)
Δs_{t-1}	.067 (.008)	.095 (.075)	.097 (.008)	.062 (.068)	.131 (.029)	.068 (.008)	.179 (.064)	.081 (.008)
Δs_{t-2}	.057 (.007)	−.005 (.072)	.086 (.008)	.016 (.064)	.100 (.026)	.064 (.008)	.157 (.060)	.076 (.009)
Δs_{t-3}	.039 (.008)	.182 (.064)	.076 (.008)	.164 (.058)	.097 (.028)	.055 (.009)	.113 (.062)	.066 (.009)
Δs_{t-4}	.042 (.008)	−.026 (.065)	.073 (.009)	−.022 (.059)	.107 (.028)	.054 (.009)	.097 (.061)	.064 (.009)
Δs_{t-5}	.032 (.008)	.158 (.070)	.069 (.009)	.195 (.064)	.071 (.029)	.062 (.009)	.069 (.060)	.068 (.009)
Δs_{t-6}	.016 (.008)	.129 (.062)	.046 (.008)	.065 (.056)	.061 (.025)	.032 (.009)	.058 (.060)	.041 (.009)
p_t	.052 (.024)	−.143 (.157)	−.043 (.025)	−.183 (.140)	.146 (.138)	−.049 (.024)	.163 (.264)	−.039 (.025)
p_{t-1}	.282 (.024)	.301 (.166)	.226 (.026)	.342 (.148)	.272 (.142)	.220 (.025)	−.003 (.278)	.215 (.026)
$\Sigma\Delta s$ Coefficients	.322 (.028)	.683 (.053)	.541 (.021)	.624 (.053)	.615 (.095)	.418 (.023)	.758 (.113)	.484 (.022)
Σp Coefficients	.334 (.022)	.157 (.023)	.182 (.010)	.159 (.023)	.418 (.092)	.172 (.011)	.160 (.055)	.176 (.010)
$di/d\Delta s$	.526	.765	.645	.699	.930	.501	.874	.576
$n(-350)$	4518	533	4518	533	139	4533	139	4534
r.d.f.	3976	523	4508	514	120	4386	116	4511
$\hat{R}^2$	.188	.354	.255	.322	.724	.162	.388	.203

$F[(4) - (2) - (3)] = 11.05$; $F[(9) - (7) - (8)] = 6.66$; $F_{.01} = 2.41$

$$\frac{di}{d\Delta s} = 0.332 + 0.052(0.684) + 0.282(0.598) = 0.526.$$

For the industry time series

$$\frac{di}{d\Delta s} = 0.615 + 0.146(0.786) + 0.272(0.732) = 0.930.$$

Here, then, we do find a close to unitary elasticity of capital stock to sales over a six year period, if profits adjust in their regression relation to prior sales changes.

Table 4-7 reveals further instability in the relations. The firm time series regressions now show larger sales change coefficients as well as larger profits coefficients in the years 1963-1968. This may relate to the more rapid growth rate of sales in the later period. The likely consequence of greater pressure on capacity might make investment more responsive to changes in the growth rate of demand.

The cross section results shown in Table 4-6 largely confirm relations already observed. The within industry firm regressions, presumably containing the largest proportion of transitory variance, yield a sum of sales change coefficients of 0.418 and a total derivative of investment with respect to sales changes of 0.501. The industry cross sections, with presumably the largest proportion of permanent variance, have a sum of sales change coefficients of 0.758 and a total derivative of 0.874. The difference between the two investment regressions is statistically significant, as shown by the F test on reduction of residual variance from the parent firm cross section across industries (where the sum of sales change coefficients was an intermediate 0.484). It should be observed that all of these regressions omit the depreciation variable, permitting comparison with the firm time series where depreciation (defined as the 1953 ratio to gross fixed assets) was not a variable. This seems to have some tendency to raise sales change coefficients. It appears possible that in more rapidly growing firms, lengths of life of capital are shorter and depreciation ratios are higher.

Table 4-8 reports cross section results by individual years. While year-to-year differences are larger than what can reasonably be attributed to chance, results are fairly consistent with each other. The chief differences readily discernible relate to the larger role of profits in later years, as noted above. Perhaps most striking about the individual year regressions is not their differences but their essential similarity. Year after year, the sum of sales change variables is significantly positive; only in one year does it differ significantly from 0.405, the sum of sales change coefficients in the pooled regression from observations of all years.

Table 4-7. Capital Expenditures as a Function of Sales Changes and Profits, Firm and Industry Time Series and Cross Sections, and Firm Overall Regressions, 1955-1962 versus 1963-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + u_t$$

(1) Variable or Statistic	(2) Firm Time Series	(3) Cross Section of Firm Means	(4) Firm Overall	(5) Cross Section of Means within Industries	(6) Industry Time Series	(7) Firm Cross Section within Industries	(8) Industry Cross Section	(9) Firm Cross Section across Industries	(10) Means and Standard Deviations[a]
A. 1955-1962									
$\Sigma\Delta s$ Coefficients	.244 (.045)	.629 (.056)	.537 (.027)	.516 (.054)	.477 (.195)	.422 (.028)	.950 (.168)	.524 (.027)	.034 (.124)
Σp Coefficients	.179 (.034)	.111 (.024)	.117 (.013)	.106 (.023)	.281 (.220)	.114 (.013)	.113 (.083)	.117 (.013)	.096 (.040)
$n(-184)$ [or i_t]	3125	523	3125	523	80	3147	80	3147	.085 (.050)
r.d.f.	2593	513	3115	504	61	3058	63	3130	
$\hat{R}^2$	.055	.264	.163	.216	.240	.120	.329	.159	
F	17.67	21.80	68.82	16.72	3.46	47.41	4.92	66.82	

$F[(4) - (2) - (3)] = 5.52; F_{.01} = 2.41.$ $F[(9) - (7) - (8)] = 9.59; F_{.01} = 2.41.$

B. 1963-1968									
$\Sigma\Delta s$ Coefficients	.403 (.065)	.520 (.065)	.468 (.036)	.519 (.069)	.961 (.201)	.399 (.040)	.546 (.148)	.423 (.037)	.100 (.114)
Σp Coefficients	.441 (.057)	.259 (.032)	.256 (.018)	.254 (.035)	.174 (.206)	.262 (.020)	.230 (.069)	.262 (.018)	.125 (.045)
$n(-166)$ [or i_t]	1353	322	1353	322	59	1386	59	1387	.122 (.061)
r.d.f.	1022	312	1343	303	40	1319	44	1372	
$\hat{R}^2$	.199	.403	.310	.352	.710	.242	.491	.289	
F	29.39	25.04	68.62	19.79	14.35	48.06	6.67	63.52	
	$F[(4)-(2)-(3)] = 5.59$; $F_{.01} = 2.41$.				$F[(9)-(7)-(8)] = 1.03$; $F_{.01} = 2.41$; $F_{.1} = 1.63$.				
F[(55-68) − (55-62) − (63-68)][b]	2.79	17.45	15.17	7.87	1.44	7.02	1.05	7.54	
$F_{.01}$	1.17	2.34	2.32	1.93	2.09	2.41	2.57	2.41	

[a]Standard deviations from firm time series; means, for corresponding observations, are for Δs_{t-1}, p_{t-1}, and i_t, respectively.
[b]For reduction in residual variance, adjusting for number of observations where necessary, from 1955-1968 regressions.

Table 4-8. Capital Expenditures as a Function of Sales Changes, Profits, and Depreciation, Individual Year and Pooled Firm Cross Sections, 1955-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + b_{10} d_{53} + u_t$$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Variable or Statistic	Years														All, Pooled	Mean 1955-1961	Mean 1962-1968
	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968			
Means and Standard Deviations																	
i_t	.073	.095	.093	.078	.082	.085	.083	.084	.087	.104	.128	.144	.150	.144	.095	.084	.120
	(.057)	(.068)	(.067)	(.066)	(.078)	(.066)	(.073)	(.072)	(.064)	(.070)	(.091)	(.100)	(.105)	(.094)	(.074)		
Δs_t	.084	.064	.023	−.039	.087	.028	.034	.095	.085	.110	.124	.127	.052	.120	.059	.040	.102
	(.129)	(.113)	(.111)	(.123)	(.122)	(.109)	(.117)	(.111)	(.114)	(.124)	(.130)	(.159)	(.171)	(.124)	(.123)		
Regression Coefficients and Their Sums and Standard Errors																	
Year Dummies from Pooled Regressions	.010	.024	.023	.014	.019	.018	.015	.016	.018	.026	.042	.054	.057	.050		.018	.038
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)	(.006)	(.006)			
Constant	.039	.038	.035	.033	.013	.037	.015	.006	.031	.035	.017	.032	.060	.038	.024	.030	.031
	(.007)	(.007)	(.006)	(.007)	(.008)	(.007)	(.007)	(.007)	(.007)	(.008)	(.011)	(.012)	(.018)	(.015)	(.002)		
Δs_t	.025	.147	.090	.144	.050	.088	.078	.034	.044	.021	.084	.034	.127	.132	.077	.089	.068
	(.023)	(.029)	(.028)	(.031)	(.033)	(.031)	(.030)	(.033)	(.031)	(.033)	(.040)	(.043)	(.048)	(.054)	(.008)		
$\Sigma\Delta s$ Coefficients	.208	.313	.396	.436	.486	.343	.427	.485	.293	.378	.399	.319	.515	.521	.405	.373	.416
	(.080)	(.078)	(.073)	(.073)	(.084)	(.075)	(.080)	(.072)	(.069)	(.073)	(.086)	(.096)	(.137)	(.110)	(.021)		
Σp Coefficients	.087	.103	.024	.004	−.033	.062	.063	.113	.216	.146	.221	.262	.178	.183	.118	.044	.188
	(.043)	(.035)	(.032)	(.034)	(.040)	(.035)	(.035)	(.035)	(.037)	(.037)	(.047)	(.049)	(.057)	(.047)	(.010)		

d_{53}	.484 (.112)	.648 (.108)	.767 (.108)	.676 (.112)	1.187 (.132)	.645 (.121)	.940 (.121)	.931 (.120)	.552 (.123)	.677 (.139)	1.080 (.187)	.964 (.223)	.392 (.340)	.614 (.257)	.747 (.036)	.764	.744
$n(-350)$	386 (−21)	492 (−31)	439 (−20)	397 (−22)	369 (−22)	383 (−29)	353 (−21)	328 (−18)	282 (−22)	264 (−25)	273 (−37)	259 (−36)	152 (−22)	157 (−24)	4534 (−350)	403	245
r.d.f.	375	481	428	386	358	372	342	317	271	253	262	248	141	146	4510		
$\hat{R}^2$	.117	.204	.268	.269	.313	.204	.308	.360	.321	.325	.345	.334	.331	.387	.270	.240	.382

$F(130, 4380) = 2.23$ for differences between years; $F_{.01} = 1.32$.

Let us also examine results by industry groups. Here again, as seen in Table 4-9, there is diversity within a pattern of overall consistency. Regression coefficients for sales change and profits variables, both in the cross sections and time series, are highest in utilities, where we have come to expect predictable, stable movements. Current and past profits and growth in sales are likely to be good proxies for future expectations and hence should relate closely to investment—and they do. It must be emphasized, however, that in each industry, in cross sections as well as in time series, the sum of sales change coefficients and the sum of profits coefficients are both positive, and for sales change coefficients almost always significantly so.

The 1957-based normalization of variables in the capital expenditure regressions discussed thus far offers certain advantages in easy interpretation and comparison of coefficients of successively lagged terms. Some divisor is desirable, as noted earlier, to eliminate heteroscedasticity associated with heterogeneity in size of firm. When all sales changes are divided by average sales of a given period, equal values of sales change variables of different years reflect equal changes in the volume of sales. Coefficients relating to different lags are hence directly comparable. Dividing capital expenditures by capital stock of the period corresponding to that of the sales average then permits direct inference about a sum of coefficients of successive sales changes.

After using this technique of normalization in early work, however, I felt some qualms. These concerned the possibility that, despite continuing efforts to eliminate from our sample firms that have merged or made major acquisitions in the period under analysis, normalization to a given past year may create increasing havoc over time. For if included firms are growing by acquisition or merger, both capital expenditures and (generally rising) sales would in later years appear to be higher ratios of 1957 capital stock and sales, respectively. Thus, for firms growing by the merger or acquisition route, the variables measuring capital expenditures, sales changes, and profits would all be higher than for firms not growing in this fashion merely because of our out of date normalization.

An alternative set of regressions was therefore calculated in which capital expenditures and profits are divided by the previous year's gross fixed assets rather than by those of 1957 and sales changes are divided by the average of current, previous, and two years previous sales rather than by those averaged around 1957. These new transformations have the drawback of eliminating a number of observations in years in which the varied divisors are not complete. They have the further effect of reversing the upward drift over the years in means and variances of the variables.

The main difference between these results (see microfiche Tables M4-10 through M4-14) and those presented above is some tendency for the sum of sales change coefficients to be smaller, except in the industry cross section reported in Table M4-10. Perhaps, more generally, it should be observed that all regression coefficients tend to be smaller. This may reflect particularly the smaller variance in the dependent variable, as may be seen immediately by contrasting the standard deviation of 0.063 for i_t^*, shown in Table M4-10, with the standard deviation of 0.077, shown for i_t in Table 4-1. Rapidly growing firms would tend to have $i_t = I_t/K_{57}$ grow rapidly over time, while $i_t^* = I_t/K_{t-1}$ would remain relatively constant or even decline in the face of a rapid rise in K_{t-1} with higher values of I. The changing denominator in the other independent variables, while also reducing variance as the years progress, may be introducing something of an additional disturbance error or transitory phenomenon that would bias coefficients toward zero.

While regression coefficients do tend to be smaller with the moving, lagged divisor, major results are essentially undisturbed. We have tried to err on what seems to be the side of caution and will focus more, in further detailed analysis of the capital expenditures function, on regressions involving i^*, that is, involving the moving, lagged divisor.

THE ROLE OF REPORTED SALES EXPECTATIONS

Current and past sales change variables have perhaps served largely as proxies for changes in the expected levels of future sales and output. Since investment should relate to expected rather than to past or current demand, we should look for more meaningful relations involving capital expenditures and expected sales changes. Such expectations may not, of course, be held with sufficient certainty to warrant investment decisions. What is more, the sales change anticipations reported in response to questionnaires may differ substantially from the expectations held by relevant decisionmakers in the firm. As noted in Chapter 2, expected sales changes reported by individual firms proved substantially inaccurate, particularly in the long run, as predictors of actual sales changes. Therefore, including expected sales change variables may bring some improvement in the fit of our investment relation but perhaps not very much.

The sales change expectation variables utilized in the investment regressions are the actual responses of the McGraw-Hill surveys. The "long-run" sales change expectation is therefore not at annual rates and covers a three year period beginning one year hence for the years 1956 through 1968; for 1958 the survey question relates to a four year period beginning immediately.

Table 4-9. Capital Expenditures as a Function of Sales Changes, Profits, and Depreciation, Cross Sections and Time Series by Industry, 1955-1968

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + b_{10} d_{53} + u_t$$

(1) Variable or Statistic	(2) Primary Metals	(3) Metal working	(4) Chemical Process-ing	(5) All Other Manufac-turing	(6) Mining	(7) Utilities	(8) Petro-leum	(9) Rail-roads	(10) Stores	(11) Transpor-tation and Communication	(12) All Industries
Means and Standard Deviations											
i_t	0.80 (0.64)	.105 (.082)	.093 (.064)	.092 (.073)	.081 (.070)	.086 (.042)	.077 (.040)	.030 (.018)	.133 (.095)	.211 (.141)	.096 (.078)
Δs_t	.035 (.132)	.082 (.173)	.075 (.126)	.052 (.109)	.064 (.169)	.061 (.074)	.079 (.106)	.009 (.090)	.063 (.105)	.107 (.114)	.004 (.131)
p_t	.062 (.043)	.145 (.111)	.110 (.096)	.142 (.125)	.096 (.073)	.041 (.013)	.078 (.089)	.021 (.016)	.165 (.134)	.042 (.043)	.110 (.107)
d_{53}	.049 (.024)	.067 (.026)	.053 (.017)	.051 (.015)	.051 (.025)	.022 (.004)	.048 (.020)	.018 (.004)	.066 (.030)	.107 (.043)	.053 (.028)
Regression Coefficients and Their Sums and Standard Errors *Cross Sections*											
Δs_t	.091 (.035)	.080 (.014)	.047 (.020)	.090 (.022)	.105 (.037)	.089 (.023)	.089 (.026)	.050 (.017)	.125 (.049)	.274 (.130)	.078 (.005)
Σs coefficients	.191 (.088)	.394 (.045)	.338 (.078)	.339 (.049)	.318 (.100)	.607 (.074)	.268 (.059)	.252 (.058)	.649 (.115)	.627 (.380)	.377 (.022)
Σp coefficients	.294 (.082)	.150 (.023)	.129 (.026)	.148 (.019)	.149 (.095)	1.361 (.207)	.038 (.029)	.156 (.068)	.205 (.039)	.644 (.360)	.145 (.011)

d_{53}	.537 (.126)	.693 (.077)	.387 (.126)	.505 (.145)	.223 (.236)	.280 (.376)	.536 (.122)	.911 (.241)	.243 (.161)	1.405 (.305)	.628 (.043)
$n(-350)$	338 (−16)	1114 (−141)	705 (−31)	765 (−30)	120 (−20)	509 (−12)	202 (−8)	243 (−9)	428 (−57)	109 (−26)	4533 (−350)
r.d.f.	314	1090	681	741	96	485	178	219	404	87	4385
$\hat{R}^2$	.179	.253	.167	.189	.195	.337	.253	.152	.165	.295	.200
F(All-individual industries) = 2.15; $F_{.01}$ = 1.39.											
Time Series											
Δs_t	.087 (.032)	.088 (.013)	.039 (.019)	.103 (.022)	.096 (.038)	.059 (.019)	.051 (.021)	.072 (.013)	.057 (.041)	.203 (.124)	.068 (.008)
$\Sigma\Delta s$ coefficients	.248 (.110)	.358 (.050)	.338 (.064)	.326 (.069)	.491 (.137)	.563 (.085)	.187 (.063)	.317 (.046)	.092 (.140)	.457 (.500)	.322 (.028)
Σp coefficients	.543 (.147)	.307 (.037)	.327 (.057)	.357 (.045)	.312 (.163)	1.332 (.140)	.381 (.123)	.192 (.120)	.240 (.082)	.855 (.517)	.334 (.022)
$n(-350)$	336	1111	704	762	119	509	199	242	426	110	4518
r.d.f.	296	962	610	659	94	457	164	207	359	87	3976
$\hat{R}^2$	.227	.287	.216	.209	.269	.321	.302	.339	.035	.029	.188
F(All-individual industries) = 2.10; $F_{.01}$ = 1.42.											

The results of the basic overall regressions for firms appear on Table 4-15.[6] The number of observations, considerably reduced because of missing information on sales change expectations, still totals 2,593. While the sum of the sales change regression coefficients is only 0.258, coefficients of each of the expected sales changes are significantly positive. The coefficients of all actual and expected sales change variables together sum to 0.344. Recognizing that the long-run sales change involves a three year figure—its mean is 0.195 as compared to a mean of 0.068 for the short-run or one year sales change expectations—we may infer that its coefficient, if it were redefined as an annual rate, would be some three times the 0.042 indicated. Hence, one might argue that the sum of all sales change coefficients, if all variables were taken at annual rates, would be in the neighborhood of 0.43. Viewed this way, or given the relative dimensions of the two variables, one would judge the longer run sales change expectations to be more potent in influencing capital expenditures.

Sales change expectations, and particularly the long-run expectations, seem more important where intraindustry, interfirm variance is washed out. As shown in Table 4-16, which offers a variety of firm cross section and industry regression results, the short-run sales change expectation in the industry cross section has a coefficient of 0.133, and the long-run expectation, a coefficient of 0.107. In the industry overall regression, the role of long-run sales expectation appears even more substantial, with a coefficient of 0.189 (standard error of 0.049). Were long-run sales change expectations defined in annual rates, the coefficient might be roughly 0.57, raising the sum of all sales change coefficients to approximately 0.93, remarkably close to unity. The sum of the profits coefficients in this regression remains a modest 0.124. In Table 4-17, in the industry time series, we see a similarly high—even higher—coefficient of 0.257 for the long-run sales change expectation variable as defined. Tripling it would in this case put the sum of all sales change coefficients somewhat above unity, approximately 1.12. In the individual firm time series, however, long-run sales change expectations have a relatively low coefficient of 0.029, perhaps again reflecting the overwhelmingly transitory nature and doubtful accuracy of short-term individual firm changes in long-run expectations. It might be added that the coefficient of determination, a modest 0.222 in the firm time series, was 0.563 in the industry time series and about the same in the industry cross section and overall regressions.

The individual firm cross section regressions by year, shown in

[6] Tables M4-10 through M4-14 appear only in microfiche.

Table 4-15. Capital Expenditures as a Function of Sales Changes, Expected Sales Changes, Profits, and Depreciation, Firm Overall Regression, 1955-1968

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j}^* + b_8 s_{t+1}^t + b_9 s_{t+4}^t + \sum_{j=10}^{11} b_j p_{t+10-j}^* + b_{12} d_{53} + u_t$$

(1) Variable or Statistic	(2) Regression Coefficients and Standard Errors	(3) Means and Standard Deviations and Products
Constant or i_t^*	.012 (.003)	.080 (.061)
Δs_t^*	.062 (.010)	.061 (.112)
Δs_{t-1}^*	.058 (.009)	.051 (.120)
Δs_{t-2}^*	.030 (.009)	.052 (.121)
Δs_{t-3}^*	.026 (.009)	.054 (.123)
Δs_{t-4}^*	.038 (.008)	.051 (.126)
Δs_{t-5}^*	.025 (.008)	.053 (.129)
Δs_{t-6}^*	.016 (.008)	.049 (.138)
s_{t+1}^t	.045 (.015)	.068 (.075)
s_{t+4}^t	.042 (.008)	.195 (.136)
p_t^*	.001 (.025)	.094 (.087)
p_{t-1}^*	.146 (.024)	.096 (.089)
d_{53}	.538 (.043)	.055 (.026)
$\Sigma\Delta s^*$ coefficients	.258 (.023)	$\sum_{j=1}^{7} b_j \cdot$ mean Δs_{t+1-j}^* = .014
$\Sigma\Delta s^* + s_{t+1}^t + s_{t+4}^t$ coefficients	.344 (.026)	$b_8 \cdot$ mean s_{t+1}^t
Σp^* coefficients	.148 (.013)	$+ b_9 \cdot$ mean s_{t+4}^t = .011
		Total = .025

Table 4-15 continued

(1) Variable or Statistic	(2) Regression Coefficients and Standard Errors	(3) Means and Standard Deviations and Products		
$n(-156)$	2593			
r.d.f.	2580	$b_{10} \cdot \text{mean } p_t^* + b_{11} \cdot \text{mean } p_{t-1}^*$	=	.014
$\hat{R}^2$	.258			
		$b_{12} \cdot \text{mean } d_{53}$	=	.030
		Constant	=	.012
		Grand Total = mean i_t^*	=	.080[a]

Note: Tables M4-10 through M4-14 appear only in microfiche.
[a]Apparent inconsistency in addition due to rounding.

Table M4-18, generally tend to confirm the positive influence of sales change expectations on capital expenditures. Year-to-year variation in the coefficients, particularly of the short-run change variable, must be noted, however. The pooled regression coefficient of short-term expected sales changes was a significant 0.052 (standard error of 0.015), but five of the fourteen individual year regressions revealed negative coefficients and that for 1966 was a whopping +0.317, to go with a negative sum of actual change coefficients! This may reflect the varying tendency to regressivity of sales change expectations and a varying positive relation with expectations of the long-run pressure of demand on capacity that would affect investment.

Breakdowns by individual industries (Table M4-19) also show some differences. In cross sections, short-run sales expectations have a very large coefficient of 0.417 in utilities, while the long-run sales change variable shows a significantly positive coefficient of 0.056 (before tripling). The sum of all sales change coefficients, with tripling of that for long-run sales expectations, is about 0.86, again suggesting that utilities are one industry where capital stock adjusts fairly closely to demand. Even in the time series, the sum of sales change coefficients for utilities is about 0.65. The profits coefficients, however, come to a very high 2.031 in the time series, as against, typically, only 0.117 in the cross section.

In transportation and communications, the coefficient of determination is a high 0.489 in both the cross section and the time series. The sales change coefficients are rather erratic, though, and much of

Table 4-16. Capital Expenditures as a Function of Sales Changes, Expected Sales Changes, Profits, and Depreciation, Cross Sections and Industry Overall Regression, 1955-1968

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s^*_{t+1-j} + b_8 s^t_{t+1} + b_9 s^t_{t+4} + \sum_{j=10}^{11} b_j p^*_{t+10-j} + b_{12} d_{53} + u_t$$

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
	Firm Cross Section			*Industry*		
Variable or Statistic	*Within industries*	*Across industries*	*Means within industries*	*Means across industries*	*Cross section*	*Overall*
Constant	.024 (.003)	.014 (.003)	.029 (.006)	.018 (.006)	−.002 (.007)	−.014 (.008)
Δs^*_t	.067 (.010)	.067 (.010)	.060 (.043)	.039 (.045)	.043 (.054)	.016 (.053)
Δs^*_{t-1}	.045 (.010)	.051 (.009)	.013 (.042)	.021 (.044)	.073 (.048)	.109 (.036)
Δs^*_{t-2}	.027 (.009)	.028 (.009)	.073 (.044)	.084 (.046)	.020 (.049)	.027 (.034)
Δs^*_{t-3}	.025 (.009)	.030 (.009)	.044 (.040)	.039 (.042)	.033 (.047)	.012 (.037)
Δs^*_{t-4}	.022 (.009)	.029 (.009)	.056 (.036)	.054 (.037)	.063 (.041)	.074 (.036)
Δs^*_{t-5}	.020 (.009)	.016 (.009)	.019 (.039)	−.006 (.041)	−.052 (.044)	.023 (.040)
Δs^*_{t-6}	.006 (.008)	.010 (.008)	.008 (.035)	.035 (.037)	.020 (.042)	.053 (.030)
s^t_{t+1}	.033 (.015)	.052 (.015)	−.083 (.048)	.000 (.049)	.133 (.090)	.052 (.078)
s^t_{t+4}	.021 (.008)	.033 (.008)	.061 (.022)	.055 (.022)	.107 (.050)	.189 (.049)
p^*_t	.012 (.024)	.005 (.025)	−.357 (.124)	−.245 (.129)	−.093 (.201)	.069 (.186)
p^*_{t-1}	.141 (.024)	.121 (.024)	.427 (.121)	.294 (.125)	.068 (.189)	.055 (.178)
d_{53}	.436 (.049)	.574 (.042)	.412 (.072)	.581 (.064)	.797 (.155)	.481 (.157)
$\Sigma\Delta s^*$ coefficients	.213 (.024)	.232 (.024)	.274 (.048)	.266 (.049)	.199 (.111)	.314 (.108)
$\sum_{j=1}^{9} b_j$	.266 (.027)	.317 (.026)	.252 (.053)	.321 (.053)	.439 (.126)	.555 (.110)
Σp coefficients	.153 (.014)	.126 (.013)	.069 (.022)	.049 (.022)	−.024 (.055)	.124 (.055)
$n(-156)$	2590	2593	388	388	120	120
r.d.f.	2461	2567	366	375	94	107
$\hat{R}^2$	.167	.238	.299	.422	.598	.579

$F[(3) - (2) - (6)] = 7.02$; $F_{.01} = 2.18$.

Table 4-17. Capital Expenditures as a Function of Sales Changes, Expected Sales Changes, and Profits, Firm and Industry Time Series and Cross Sections and Firm Overall Regressions, 1955-1968

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j}^* + b_8 s_{t+1}^t + b_9 s_{t+4}^t + \sum_{j=10}^{11} b_j p_{t+10-j}^* + u_t$$

(1) Variable or Statistic	(2) Firm Time Series	(3) Cross Section of Firm Means	(4) Firm Overall	(5) Cross Section of Means within Industries	(6) Industry Time Series	(7) Firm Cross Section within Industries	(8) Industry Cross Section	(9) Firm Cross Section across Industries
Constant	.018 (.003)	.034 (.006)	.033 (.002)	.046 (.006)	.026 (.010)	.044 (.002)	.003 (.008)	.036 (.002)
Δs_t^*	.047 (.010)	.035 (.049)	.065 (.010)	.051 (.045)	.055 (.045)	.068 (.010)	.053 (.060)	.073 (.010)
Δs_{t-1}^*	.037 (.009)	.012 (.049)	.064 (.009)	.007 (.044)	.101 (.030)	.047 (.010)	.127 (.053)	.058 (.010)
Δs_{t-2}^*	.014 (.009)	.134 (.050)	.037 (.009)	.106 (.046)	.022 (.029)	.032 (.010)	.063 (.054)	.039 (.010)
Δs_{t-3}^*	.019 (.009)	.022 (.047)	.035 (.009)	.036 (.042)	.003 (.032)	.030 (.009)	.044 (.053)	.040 (.009)
Δs_{t-4}^*	.031 (.009)	.050 (.041)	.047 (.009)	.049 (.037)	.058 (.031)	.028 (.009)	.078 (.046)	.039 (.009)
Δs_{t-5}^*	.018 (.008)	.032 (.045)	.034 (.009)	.047 (.041)	.015 (.034)	.028 (.009)	−.022 (.049)	.030 (.009)
Δs_{t-6}^*	.012 (.008)	.063 (.040)	.025 (.008)	.025 (.037)	.058 (.026)	.014 (.008)	.040 (.047)	.023 (.008)
s_{t+1}^t	.053 (.015)	.032 (.054)	.054 (.015)	−.093 (.050)	.035 (.064)	.031 (.015)	.247 (.098)	.063 (.015)
s_{t+4}^t	.029 (.009)	.089 (.024)	.059 (.009)	.077 (.023)	.257 (.052)	.028 (.008)	.169 (.054)	.049 (.008)
p_t^*	.168 (.025)	−.252 (.142)	.013 (.026)	−.386 (.129)	.106 (.156)	.013 (.025)	.050 (.224)	.014 (.026)
p_{t-1}^*	.285 (.025)	.330 (.138)	.154 (.025)	.461 (.126)	.286 (.150)	.148 (.024)	.031 (.213)	.135 (.025)
$\Sigma\Delta s^*$ coefficients	.179 (.032)	.347 (.053)	.307 (.024)	.321 (.050)	.312 (.106)	.247 (.024)	.383 (.119)	.302 (.024)
$\sum_{j=1}^{9} b_j$	.261 (.036)	.468 (.055)	.419 (.026)	.305 (.055)	.605 (.112)	.306 (.027)	.798 (.118)	.414 (.026)
Σp^* coefficients	.453 (.024)	.077 (.024)	.167 (.013)	.075 (.023)	.391 (.076)	.161 (.014)	.080 (.057)	.148 (.013)
$n(-156)$	2535	388	2535	388	120	2590	120	2593
r.d.f.	2136	376	2523	367	99	2462	95	2568
$\hat{R}^2$	.222	.297	.207	.238	.563	.140	.490	.183

$F[(9) - (7) - (8)] = 11.32$; $F_{.01} = 2.25$.

the explanation of the high coefficient of determination relates to the profits and depreciation coefficients. Possibly vitiating these findings, the number of observations in transportation and communications is relatively small, with only 45 and 43 residual degrees of freedom in each regression.[7]

UTILIZATION OF CAPACITY AND OTHER VARIABLES

If sales changes and sales change expectations are relevant essentially because they measure expected pressure of demand on capacity, which in turn relates to the expected profitability of investment, looking for more direct measures of these determinants of capital expenditures is in order. With regard to utilization of capacity, the McGraw-Hill questionnaires have variously included two questions, one relating to the actual percent utilization of capacity and the other to the preferred utilization rate. By dividing the actual by the preferred utilization rate, we are able to normalize the relationship between industries and firms and even adjust to changes over time of firms' views on optimal utilization. Since, however, the question regarding preferred utilization was not asked in every year and firms did not always respond, our normalized utilization variable was defined as actual utilization divided by the last reported preferred utilization. The number of observations was further reduced because the utilization of capacity questions were apparently considered inappropriate and therefore not included in the questionnaires for a number of industries.

The role of the utilization of capacity variable, u^c_{t-1}, is illustrated in Table 4-25,[8] where the capital expenditure ratio is also shown as a function of current and past sales changes and profits and of the 1953 depreciation ratio. In the firm overall regression, the coefficient of the utilization of capacity variable is a highly significant but rather small 0.062. In one sense, it might be argued that a major part of capital expenditures is accounted for by utilization of capacity (the mean of utilization of capacity variable is 0.907 and the mean of the capital expenditure ratio is 0.078). If the utilization of capacity variable were zero, the ratio of capital expenditures to gross fixed assets, according to this regression, would be reduced by 0.056, or

[7] Tables M4-20 through M4-24 are analogous to Tables 4-15 through M4-19, but use 1957-centered divisors for capital expenditure, sales change, and profits variables. Sales change coefficients are generally higher, but expected sales change coefficients appear smaller than those in the tables where immediately lagged divisors are used.

[8] Tables M4-18 through M4-24 appear only in microfiche.

Table 4-25. Capital Expenditures as a Function of Sales Changes, Utilization of Capacity, Profits, and Depreciation, Firm and Industry Overall Regressions, 1955-1968

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j}^* + b_8 u_{t-1}^c + \sum_{j=9}^{10} b_j p_{t+9-j}^* + b_{11} d_{53} + u_t$$

(1)	(2)	(3)	(4)
	Regression Coefficients and Standard Errors		
Variable or Statistic	Firm	Industry	Means and Standard Deviations and Products
Constant	−.026 (.010)	−.104 (.038)	.078 (.055)
Δs_t^*	.052 (.012)	.002 (.052)	.060 (.117)
Δs_{t-1}^*	.034 (.010)	.002 (.037)	.047 (.127)
Δs_{t-2}^*	.023 (.010)	.028 (.032)	.050 (.131)
Δs_{t-3}^*	.026 (.010)	−.007 (.035)	.049 (.130)
Δs_{t-4}^*	.039 (.010)	.090 (.034)	.058 (.131)
Δs_{t-5}^*	.032 (.009)	.053 (.036)	.052 (.139)
Δs_{t-6}^*	.018 (.009)	.053 (.032)	.050 (.145)
u_{t-1}^c	.062 (.010)	.135 (.037)	.907 (.129)
p_t^*	−.008 (.027)	−.023 (.153)	.103 (.094)
p_{t-1}^*	.128 (.026)	.239 (.147)	.106 (.095)
d_{53}	.402 (.055)	.414 (.292)	.057 (.023)
$\Sigma\Delta s$ coefficients	.223 (.027)	.221 (.121)	
Σp coefficients	.120 (.014)	.217 (.058)	
$n(-108)$	1620	84	
r.d.f.	1608	72	
$\hat{R}^2$	.203	.478	
$\sum_{j=1}^{7} b_j \cdot \text{mean } \Delta s_{t+1-j}^*$	.012	.012	
$b_8 \cdot \text{mean } u_{t-1}^c$	.056	.122	
b_9 mean $p_t^* + b_{10} \cdot \text{mean } p_{t-1}^*$	.013	.023	

Table 4-25 continued

(1) Variable or Statistic	(2) Regression Coefficients and Standard Errors: Firm	(3) Industry
$b_{11} \cdot$ mean d_{53}	.023	.024
Constant	−.026	−.104
Total = mean i_t^*	.078	.078[a]

[a]Apparent inconsistency in addition due to rounding.

Note: Tables M4-18 through M4-24 appear only in microfiche.

almost three-quarters. In fact, since the variable's standard deviation is 0.129, the variation in capital expenditures usually associated with capacity utilization, while not trivial, is clearly considerably smaller. Indeed, another norm against which to evaluate the variable's coefficient would be unity, on the assumption that we are dealing with equilibrium relations in which capital stock adjusts fully to changes in capacity utilization. Then a 10 percent excess of utilization over the ratio desired should be expected to generate a 10 percent increase in capital stock. All this, of course, would be abstracting from the role of other factors of production, expectations, adjustment costs, errors in variables, and lags.

A higher utilization of capacity coefficient, 0.135, can be observed in the industry overall regression shown in Table 4-25. The sum of profits coefficients here is 0.217, as against 0.120 in the firm overall regression, and the coefficient of determination is a respectable 0.478.

The profits coefficients, as might have been expected, are higher again in the time series results (Table M4-26). Of particular note is the capacity utilization coefficient of 0.148 in the industry time series, which has a coefficient of determination of 0.561. Since the coefficient is essentially zero in the industry cross section regression (results not shown), we may infer that the relationship between capacity utilization and capital expenditures essentially involved covariance over time of industry means. The lack of much cross-sectional relationship, particularly across industries, may reflect the difficulty, even with our normalization, of defining a utilization of capacity variable that is meaningful for interindustry comparisons.

Examination of the results by industry (Table 4-27)[9] reveals

[9]Table M4-26 appears only in microfiche.

Table 4-27. Capital Expenditures as a Function of Sales Changes, Utilization of Capacity, Profits, and Depreciation, Cross Section and Time Series by Industry, 1955-1968

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j}^* + b_8 u_{t-1}^c + \sum_{j=9}^{10} b_j p_{t+9-j}^* + b_{11} d_{53} + u_t$$

(1) Variable or Statistic	*(2)* Primary Metals	*(3)* Metal-working	*(4)* Chemical Process-ing	*(5)* All Other Manufac-turing	*(6)* Mining	*(7)* Petro-leum	*(8)* All Industries
			Means and Standard Deviations[a]				
i_t^*	.070	.086	.074	.074	.080	.071	.078
	(.068)	(.060)	(.047)	(.051)	(.061)	(.040)	(.055)
Δs_t^*	.031	.075	.063	.043	.036	.057	.059
	(.132)	(.135)	(.104)	(.092)	(.125)	(.068)	(.117)
u_{t-1}^c	.856	.883	.924	.930	.956	.967	.907
	(.186)	(.136)	(.106)	(.101)	(.091)	(.083)	(.129)
p_t^*	.052	.123	.086	.126	.121	.052	.103
	(.037)	(.100)	(.081)	(.108)	(.092)	(.020)	(.094)
d_{53}	.049	.067	.053	.050	.067	.049	.057
	(.023)	(.026)	(.016)	(.017)	(.033)	(.024)	(.023)
			Regression Coefficients and Their Sums and Standard Errors				
			Cross Sections				
Δs_t^*	.115	.068	.049	.083	−.556	.188	.065
	(.044)	(.019)	(.024)	(.029)	(1.381)	(.062)	(.012)
Σs^* coefficients	.456	.214	.197	.135	−1.066	.492	.230
	(.111)	(.047)	(.053)	(.068)	(2.769)	(.110)	(.029)
u_{t-1}^c	−.044	.043	.106	−.011	−.290	.137	.038
	(.036)	(.019)	(.022)	(.025)	(.609)	(.046)	(.011)
Σp^* coefficients	.350	.122	.055	.094	−.312	−.727	.097
	(.148)	(.026)	(.028)	(.026)	(.775)	(.273)	(.015)
d_{53}	.009	.350	.415	.722	1.972	1.102	.412
	(.206)	(.081)	(.135)	(.164)	(4.587)	(.159)	(.056)
$n(-108)$	154	596	403	347	21	88	1616
r.d.f.	129	571	378	322	1	63	1525
$\hat{R}^2$	.194	.189	.169	.165	−.886	.517	.162
			Time Series				
Δs_t^*	.138	.032	.055	.075	−.317	−.030	.030
	(.047)	(.018)	(.022)	(.031)	(.147)	(.047)	(.012)
$\Sigma\Delta s^*$ coefficients	.361	.052	.091	−.022	−1.058	−.168	.072
	(.171)	(.056)	(.072)	(.101)	(.499)	(.126)	(.038)
u_{t-1}^c	.007	.065	.134	.033	.008	.021	.068
	(.027)	(.021)	(.022)	(.030)	(.187)	(.035)	(.011)

Table 4-27 continued

(1) Variable or Statistic	*(2)* Primary Metals	*(3)* Metal-working	*(4)* Chemical Process-ing	*(5)* All Other Manufac-turing	*(6)* Mining	*(7)* Petro-leum	*(8)* All Industries
Σp^* coefficients	1.368 (.217)	.353 (.037)	.425 (.059)	.318 (.051)	−.092 (.406)	1.245 (.242)	.382 (.026)
$n(-108)$	152	580	398	334	22	86	1572
r.d.f.	118	478	332	271	9	62	1320
$\hat{R}^2$	.399	.271	.355	.140	.223	.354	.221

[a]Overall standard deviations, based on observations used in time series.

Note: Table M4-26 appears only in microfiche.

higher coefficients for capacity utilization in chemical processing, both in the cross sections and time series; small nonsignificant coefficients in primary metals and all other manufacturing; and a rather large positive coefficient in the cross section for petroleum. The large metalworking group shows about average coefficients for capacity utilization in both time series and cross sections. In mining the usually unreliable data offered too few observations for any meaningful inference, and observations were either inadequate or completely nonexistent in utilities, railroads, stores, and other transportation and communications. The cross section regressions by year (shown in Table M4-28) indicate somewhat larger utilization coefficients in the years 1966 through 1968, but coefficients of determination are frequently low, and the various coefficients bounce about a good bit from year to year.

As indicated before, the pressure of demand on capacity should, in principle, relate to investment via its effect on the latter's expected profitability. Following the Keynesian formulation, this may be expressed in terms of the effects on the ratios of demand price to supply price of capital or of the market value of shares of existing capital to the cost of producing new capital goods. Note that the expected profitability of investment may be closely related to but is far from identical with the rate of return on existing capital. To the extent that it measures the ratio of returns expected by the firm to its current market value, the rate of return is a measure of the cost of capital and should be negatively related to current investment.

In an attempt to explore these matters, a special set of financial data was collected for the years 1959 to 1962 for the firms in the

McGraw-Hill sample. This enabled us to construct measures of the ratio of (1) earnings to market values of the firm, r, (2) market value of the firm to net worth plus depreciation reserve plus bonded indebtedness, m, and (3) the change in market value of the firm, Δv. Table 4-29,[10] covering only the years 1960 through 1962, thus adds r and m to the familiar sales change, profits, and depreciation variables. Both of these additional variables are introduced in current and lagged form, with sums and standard errors of sums of current and lagged coefficients again presented to get around problems of multicollinearity. Results, however, are somewhat disappointing. It might have been expected that m, the value of the firm ratio, would be positively associated with capital expenditures, but this is not confirmed in the coefficients for any of the individual firm regressions, and in the industry regressions, the number of observations was insufficient to warrant their presentation.[11]

With regard to r, the rate of return measure, it was thought that in a regression already including profits, its coefficients would prove negative. For when profit expectations are higher than current profits, the value of the firm would be relatively higher, and the current rate of return lower, while with generally high profit expectations, the marginal efficiency of investment would probably be greater and capital expenditures higher. Some support for this chain of reasoning may be noted in the time series results, where the sum of the coefficients of rates of return is indeed negative and significantly so.

We may recall that the variable measuring rates of return includes depreciation charges in the numerator and that time series variation in depreciation involves, at least in part, changes stemming from application of the accelerated depreciation provisions of the Internal Revenue Act of 1954. The negative time series coefficients of "rates of return" would thus appear also to imply a contradiction of the sometimes asserted argument that higher depreciation charges, per se, bring about higher rates of investment. On the other hand, the rate of return variable, which includes interest payments in the numerator, may be taken as a measure, although imperfect, of the cost of capital. It may then be argued that its negative coefficient reflects the expected negative relation between capital expenditures and the cost of capital.

[10] Table M4-28 appears only in microfiche.

[11] The value of the firm ratio might appear conceptually better if the depreciation reserve were netted out of the denominator, which denotes essentially the accounting value of the firm. It is doubtful, however, whether this change would significantly affect the results, particularly in view of the dubious quality of the relation between accounting and economic depreciation.

Table 4-29. Capital Expenditures as a Function of Sales Changes, Profits, Rate of Return, Value of the Firm Ratio, Depreciation, and Trend, Firm Time Series, Cross Section and Overall Regressions, 1960-1962

$$i_t = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j} + \sum_{j=8}^{9} b_j p_{t+8-j} + \sum_{j=10}^{11} b_j r_{t+10-j} + \sum_{j=12}^{13} b_j m_{t+12-j} + b_{14} d_{53} + b_{15} T + u_t$$

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
	Regression Coefficients and Standard Errors				
		Firm Cross Section			
Variable or Statistic	*Firm time series*	*Within industries*	*Across industries*	*Firm overall*	*Means and Standard Deviations*
Constant term or i_t				−.003 (.011)	.082 (.070)
$\Sigma\Delta s$ coefficients	.140 (.162)	.395 (.058)	.431 (.057)	.431 (.057)	
p_t	.219 (.082)	−.032 (.074)	−.052 (.074)	−.053 (.074)	.081 (.085)
p_{t-1}	.270 (.091)	.102 (.074)	.058 (.074)	.059 (.073)	.082 (.085)
r_t	−.281 (.117)	−.007 (.096)	−.011 (.096)	−.009 (.094)	.108 (.046)
r_{t-1}	−.118 (.114)	.015 (.091)	.087 (.092)	.084 (.090)	.104 (.047)
m_t	−.015 (.012)	−.002 (.009)	.003 (.009)	.003 (.009)	.938 (.597)
m_{t-1}	.013 (.010)	.008 (.008)	.006 (.008)	.006 (.008)	.990 (.607)
d_{53}	– –	.785 (.100)	.989 (.083)	.988 (.083)	.055 (.030)
T	−.003 (.003)	– –	– –	−.002 (.003)	.958 (.820)
Σp coefficients	.488 (.123)	.070 (.038)	.006 (.036)	.006 (.036)	
Σr coefficients	−.399 (.166)	.008 (.070)	.075 (.068)	.076 (.068)	
Σm coefficients	−.002 (.017)	.006 (.006)	.009 (.006)	.009 (.006)	
$n(-52)$	606	669	669	669	
r.d.f.	373	625	651	653	
$\hat{R}^2$	.055	.235	.356	.355	

F ratio for differences of regressions of firm time series and cross sections of firm means was 1.52 (14, 591), not significant at the 0.05 probability level, and hence no differences of coefficients are presented.

Note: Table M4-28 appears only in microfiche.

Table 4-30. Capital Expenditures as a Function of Sales Changes and Profits Measured as Ratios of Lagged Gross Fixed Assets and Average Sales, Change in Value of Firm, and Depreciation, Firm and Industry Cross Sections and Firm Time Series and Overall Regressions, 1961-1962

$$i_t^* = b_0 + \sum_{j=1}^{7} b_j \Delta s_{t+1-j}^* + \sum_{j=8}^{9} b_j p_{t+8-j}^* + \sum_{j=10}^{11} b_j \Delta v_{t+10-j} + b_{12} d_{53} + u_t$$

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Regression Coefficients and Standard Errors					Differences in Coefficients and Standard Errors	
Variable or Statistic	Firm time series	Cross section of firm means[a]	Firm cross section within industries	Firm overall	Industry cross section	Cross section of firm means – firm time series [(3) – (2)]	Means and Standard Deviations
Constant term or i_t^*				.018 (.004)			.063 (.050)
Δs_t^*	.027 (.036)	.031 (.048)	.026 (.021)	.000 (.021)	–.417 (.118)	.004 (.060)	.052 (.103)
Δs_{t-1}^*	.059 (.042)	–.041 (.058)	.038 (.020)	.045 (.020)	.080 (.146)	–.100 (.072)	.018 (.101)
Δs_{t-2}^*	.091 (.050)	.102 (.061)	.062 (.018)	.070 (.018)	.280 (.161)	.011 (.079)	.060 (.119)
...	...	...	...	...	...	...	...
Δv_t	.012 (.012)	–.034 (.022)	–.003 (.010)	.014 (.008)	.062 (.039)	–.046 (.025)	.049 (.248)
Δv_{t-1}	–.001 (.012)	.095 (.019)	.020 (.009)	.027 (.008)	.170 (.049)	.096 (.023)	.070 (.264)

d_{53}	–	–	.470	.574	.433	–	.055
	–	–	(.083)	(.068)	(.247)	–	(.029)
$\Sigma\Delta s^*$ coefficients	.078	.276	.189	.198	.119	.198	
	(.211)	(.062)	(.047)	(.046)	(.180)	(.220)	
Σp^* coefficients	.385	.003	.093	.067	–.144	–.382	
	(.138)	(.035)	(.026)	(.025)	(.095)	(.142)	
$\Sigma\Delta\nu$ coefficients	.010	.061	.017	.041	.232	.051	
	(.022)	(.021)	(.014)	(.013)	(.065)	(.030)	
$\Sigma\Delta s^* + \Delta\nu$ coefficients	.089	.337	.206	.239	.351	.248	
	(.212)	(.060)	(.047)	(.045)	(.163)	(.220)	
$\Sigma p^* + d_{53}$ coefficients	–	–	.563	.641	.289	–	
	–	–	(.087)	(.072)	(.293)	–	
$n(-23)$	464	232	540	540	20		
r.d.f.	221	220	508	527	6		
$\hat{R}^2$	.057	.294	.166		.879	$F(11, 452) = 3.42$[b]	

[a]Time series observations only.

[b]The corresponding 1 percent point for the distribution of F is approximately 2.29.

A variable measuring the change in value of the firm, Δv, is introduced in Table 4-30, for the years 1961 and 1962 only. It indicates that, even given past sales changes, the rate of investment tends to be positively related to the market's evaluation of the firm both for the current year and the past year. However, the variable seems essentially to be picking up effects attributed to corresponding Δs (sales change) variables. This suggests that, at least insofar as investment is concerned, "the market" did little more than project current sales changes. The sum of the Δv coefficients was somewhat larger in the cross section of firm means and largest in the industry cross section, where it amounted to 0.232, with a standard error of 0.065. One may infer that the transitory year-to-year variation in market value of individual firms tends to bias our estimates of these coefficients downward.

SUMMARY AND CONCLUSIONS

On the basis of estimating capital expenditures as a distributed lag function of seven current and past actual sales changes, current and lagged profits, and depreciation charges, the bulk of net investment is found to be accountable to increases in sales, with a "hump" in the distribution at a one year lag. In individual firm regressions, coefficients of sales change variables sum to no more than 0.5, not the value of unity to be expected from linear, homogeneous production functions, unitary elasticity of expectations, isoelastic shifts in demand, and sufficient time for adjustment. It should be noted, however, that the full role of sales changes involves also their positive relation with profits, in turn also positively related to capital expenditures.

In estimates of the factors affecting capital expenditures, significant differences emerge when time series and cross section slices of the same body of data are taken at the levels of the firm and of broad industry groups. We have tried to relate these to differing permanent and transitory components in the relevant variances and covariances. For example, the role of past sales changes, presumably as a proxy for expected long-run pressure of demand on capacity, appears greatest in the case of industry cross sections, and large in cross sections of firms across industries, particularly in cross sections of firm means. The coefficients of past sales changes are correspondingly lower in the within industry cross sections.

The variance of past sales changes about the mean of sales changes for each individual firm (firm time series) has significantly less to do with the variance in capital expenditures than the corresponding variances in the firm cross sections. This is consistent with the view that firms look upon the short-run variance in their own sales as mostly transitory.

Coefficients of sales changes are generally higher in industry time series than in firm time series, lending support to the hypothesis of a greater permanent component in industry sales change variance over time. Coefficients of sales changes also prove higher as time series become longer in duration.

New light is cast on the role of profits in distributed lag investment functions including a considerable number of lagged sales changes. While coefficients of the profit variables are uniformly low in cross sections, they are relatively high in most of the time series. Firms apparently tend to make capital expenditures in the period immediately following higher profits, but firms earning higher profits do not make markedly greater capital expenditures than firms earning lower profits. This evidence is consistent with the hypothesis that past profits play some significant role in the timing of capital expenditures but do not affect the long-run average. Sales changes, however, show a double effect on investment, once directly and once via profits, particularly in the time series.

Expected sales changes may play some role in capital expenditures over and above that noted in current and lagged actual sales changes. The change expected over the ensuing four year period, in particular, is positively related to capital expenditures.

As to earnings, the rate of return on market value of the firm does not prove statistically significant in the cross sections, but its coefficient is distinctly negative in the firm time series. One may presume that expected future earnings are positively related to the expected profitability of investment, and hence to investment itself, as well as to the value of the firm. Given current profits, the observed negative relation between capital expenditures and rate of return could then be attributed to fluctuations in expected earnings. This is consistent with the general hypothesis that expected future earnings (long-run or permanent income) play an underlying role in the investment function. Some confirmation may be found in positive coefficients of variables measuring changes in the value of the firm, but none in the coefficients of the ratio of the firm's market value to a "book value" constructed as the sum of net worth, depreciation reserves, and bonded indebtedness.

Finally, further evidence of the role in capital expenditures of the pressure of demand on capacity appears in positive coefficients of the ratios of actual to preferred rates of capacity utilization.

APPENDIX
DEFINITIONS AND SOURCES OF VARIABLES AND INTERVALS FOR ACCEPTABLE VALUES

Symbol	*Description*[a]	*Source*[b]	*Acceptable Interval*[c]
$i_t = \dfrac{I_t}{K_{57}}$	Capital expenditures in 1954 dollars as ratio of 1957 gross fixed assets	MH/FD	[0.6, 0)
$i_t^* = \dfrac{I_t}{K_{t-1}}$	Capital expenditures in 1954 dollars as ratio of previous gross fixed assets	MH/FD	[0.6, 0)
$i_{t+1}^t = \dfrac{I_{t+1}^t}{K_{57}}$	Capital expenditure anticipations one year ahead as ratio of 1957 gross fixed assets	MH/FD	[0.6, 0)
$\Delta s_t = \dfrac{3(S_t - S_{t-1})}{S_{56}+S_{57}+S_{58}}$	Relative sales change ratio, price-deflated, 1956-1958 denominator	FD	[0.7, −0.6]
$\Delta s_t^* = \dfrac{3(S_t - S_{t-1})}{S_t+S_{t-1}+S_{t-2}}$	Relative sales change ratio, price-deflated, previous three year denominator	FD	[0.7, −0.6]
$p_t = \dfrac{P_t}{K_{57}}$	Net profits in 1954 dollars as ratio of 1957 gross fixed assets	FD	[0.7, −0.4]
$p_t^* = \dfrac{P_t}{K_{t-1}}$	Net profits in 1954 dollars as ratio of previous price-deflated gross fixed assets	FD	[0.7, −0.4]

Symbol	*Description*[a]	*Source*[b]	*Acceptable Interval*[c]
$p_{pt} = \frac{P_t}{K_{p,t-1}}$	Net profits in 1954 dollars as ratio of price-deflated gross fixed assets[a]	FD	[0.7, −0.4]
$d_{53} = \frac{D_{53}}{K_{53}}$	1953 depreciation charges as ratio of 1953 gross fixed assets	FD	[0.2, 0]
$s_{t+4}^t = \frac{S_{t+4}^t - S_t}{S_t}$	Long-run expected sales change over four years, from McGraw-Hill surveys of 1952 to 1955 = expected percent change in the physical volume of sales over four years, converted to pure decimal	MH	[1, −0.4]
$s_{t+1}^t = \frac{S_{t+1}^t - S_t}{S_t}$	Short-run sales expectations = expected percent change in the physical volume of sales from McGraw-Hill survey, converted to pure decimal	MH	[0.7, −0.6]
$u_t^c = \frac{u_t^a}{u_t^p}$	Ratio of actual to preferred rate of utilization of capacity	MH	[1.3, 0.3]
$V_t = B_t + F_t$	Market value of firm = sum of end of year bonded indebtedness and market value of common and preferred stock	FD	—

Symbol	Description[a]	Source[b]	Acceptable Interval[c]
$r_t = \dfrac{P' + D_t + Z_t}{V_t}$	Rate of return = (net profits + depreciation charges + interest payments) ÷ market value of firm	FD	[0.7, −0.4]
$m_t = \dfrac{V_t}{NW_t + R_t + B_t}$	Ratio of market value of firm to net worth + depreciation reserve + bonded indebtedness	FD	[5, 0.1]
$\Delta v_t = \dfrac{V_t - V_{t-1}}{V_{t-1}}$	Relative change in market value of firm	FD	[1.5, −0.75]
T	Time trend integer, beginning with zero for first year of dependent variable	—	[7, 0]

[a]All flow variables (I, I^t_{t+1}, S, and P) except depreciation charges (D) and rate of return (r) are price-deflated. No stock variables are price-deflated.

[b]MH = McGraw-Hill surveys.

FD = Financial data, generally from Moody's.

MH/FD = Numerator from McGraw-Hill and denominator from financial data.

[c][U, L] = Closed interval, including upper and lower bounds.

[U, L) = Interval including upper bound but not lower bound.