A Panel Study of Investment: Sales, Cash Flow, the Cost of Capital, and Leverage

Richard W. Kopcke
with Mark M. Howrey

Vice President and Economist, and Senior Research Assistant, respectively, Federal Reserve Bank of Boston.

A previous article compared the volume of aggregate investment spending by businesses during the 1980s and early 1990s to projections of spending derived from several basic models of investment (Kopcke 1993). According to these models, capital spending seems to be following a course, familiar from previous business cycles, that corresponds fairly closely with output, profits, and the cost of capital. If the composition of saving, the burden of debt, the supply of credit by commercial banks, or a shift of investors' attention from long-term opportunities to short-term earnings have depressed capital spending during the recent business cycle, the gravity of these forces has not increased conspicuously since the 1960s and 1970s.

The previous research essentially treats all businesses as one enterprise, thereby "averaging out" the decisions of thousands of investors. While a study of aggregate investment can describe accurately the course of total capital spending, by design it cannot describe the distribution of spending. Although the burden of debt, for example, may not have depressed total investment in an unusual way, the difference in leverage among corporations may account for the differences in their capital budgets.

This article compares the investment spending for each of 396 corporations during the late 1980s and early 1990s to projections of their spending derived from models similar to those used for the study of aggregate investment. Similar to the results for aggregate investment, the capital spending for the corporations in this sample did not appear to be surprisingly low, on average, after taking output, profits, and the cost of capital into account. Although the investment spending of many of these corporations often diverged substantially from the course predicted by their sales, profits, or cost of capital, the vigorous spending of some generally offset the torpid spending of others.

This substantial variance in experience suggests that, for explaining the capital spending of specific corporations, the general models used here are far from complete. Nevertheless, the missing elements seem to be idiosyncratic and difficult to specify. For example, the distribution of forecast errors for corporations with substantial leverage is very similar to the distribution of errors for those with the least leverage. Accordingly, the consideration of leverage, at best, contributes negligibly to the performance of the models. The distribution of errors also has no evident relationship to the variance of cash flow, size, average rate of growth, dividend payment rates, or industrial classification of these corporations. Rather than lacking some universal element such as leverage, the models of investment for each of these corporations appear to lack details specific to each enterprise, its markets, or its technology.

For macroeconomic policy, the disappointing rate of investment by businesses since the 1980s appears to be a general symptom of the relatively slow growth of sales and profits during this economic recovery. Both in the previous study of the total investment spending by all businesses and in this study of investment by specific corporations, those variables commonly mentioned as extraordinary impediments to capital spending appear to correspond little to the pattern of investment.

The first section of this article describes the sample of corporations and the data used in the study. This section also introduces the statistical models, describing their ability to fit the data during the 1970s and early 1980s and to forecast investment spending since the middle 1980s. The second section evaluates the potential contribution of various measures of leverage and liquidity to the performance of these statistical models. The third section is the conclusion.

Table 1
The Models of Investment

Accelerator	$I_t = a + \sum_{i=0}^{n} b_i Q_{t-i} + cK_{t-1}$
Neoclassical	$I_t = a + \sum_{i=0}^{n} b_i \frac{S_{t-i}}{UCC_{t-i}} + cK_{t-1}$
Cash Flow	$I_t = a + \sum_{i=0}^{n} b_i \left(\frac{F}{C}\right)_{t-i}$
q	$I_t = a + \sum_{i=0}^{n} b_i (q_{t-i} K_{t-1-i}) + cK_{t-1}$

Explanation of Symbols
C: price index for capital goods
F: cash flow
I: real investment
K: real stock of capital
q: ratio of financial market valuation of assets to the replacement cost of assets
Q: real sales
S: nominal sales
UCC: user cost of capital

I. Models of Investment Spending

Investments are undertaken in anticipation of profit. Assuming that investors' views of the future are grounded in their past experience, statistical models of investment spending use various measures of current and past business conditions to assess investors' perceptions of returns and thereby determine their demand for capital goods.

This article uses four different models to describe the capital spending for its sample of corporations (Table 1).[1] Each represents one way that business conditions may influence the demand for capital. The accelerator model compares the recent trend in sales or output to existing productive capacity in order to estimate investors' demands for new capital goods. The neoclassical model essentially extends the accelerator model by permitting the correspondence between output and capital to vary with the cost of capital, which includes corporate income taxes, and the relative price of investment goods. The cash flow model emphasizes the importance of internal funds, which both fund new investments and indicate the profitability of past investments. Finally, the q model highlights the correspondence between the value of corporations in financial markets and their demand for new capital.

These four models are very basic.[2] Analysts often combine elements from each in order to analyze the effects of policy on investment or to improve fore-

[1] See Kopcke (1993), Berndt (1991), Chirinko (1993), Jorgenson and Siebert (1968), and Jorgenson (1971) for more discussion of these types of models.

[2] For examples of policy analysis, see Bosworth (1985), Auerbach (1991), Henderson with Liebman (1992), and Fazzari (1993). For other studies of investment by specific corporations or industries, see Jorgenson and Siebert (1968), Jorgenson (1971), Elliott (1973), Fazzari, Hubbard and Petersen (1988), Cantor (1990), Galeotti and Schiantarelli (1991), Morrison (1992), Hayashi and Inoue (1991), Hubbard, Kashyap and Whited (1993), Oliner and Rudebusch (1993), and Sharpe (1993) as well as the studies surveyed by these articles.

Table 2
Summary Statistics for the 396 Companies, 1992

	Average	Maximum	Top Quartile	Median	Bottom Quartile	Minimum
Millions of 1987 Dollars						
Real Sales[a]	1,977	93,068	1,267	269	79	1
Real Cash Flow[b]	221	8,944	124	20	4	−1,689
Real Total Assets[c]	2,898	184,632	1,422	317	83	2
Millions of Dollars						
Nominal Sales	2,771	130,590	1,777	375	111	1
Nominal Cash Flow	242	9,881	138	22	4	−1,577
Nominal Total Assets	2,742	191,012	1,568	303	77	1
Percent						
Debt/Asset Ratio	23.3	163.4	33.2	21.0	9.5	.0
Short-Term Debt/Asset Ratio	6.4	159.4	6.1	3.2	.9	.0
Payout[d]		1955.0	77.2	39.7	5.1	−.1
Real Asset Growth	1.6	145.0	5.4	−.1	−3.7	−32.0
q	124.0	949.4	138.4	88.6	68.6	11.4
Cash Flow coverage[e]	2,822.8	404,500.0	1,020.6	442.0	174.8	−10,400.0
Income Coverage[f]	2,803.1	291,600.0	1,065.4	429.6	149.8	−174.1
Investment Grade Rating[g]	77.6					

[a]Real sales used in accelerator model.
[b]Real cash flow used in cash flow model.
[c]Real total assets calculated by adjusting nominal total assets (less property, plant, and equipment) using the consumer price index, and adding real capital stock (see Appendix I).
[d]Payout defined as cash dividends as a percent of cash flow before extraordinary items. An average was not calculated since there were negative cash flows, which would bias the average.
[e]Coverage is cash flow divided by interest expense.
[f]Interest coverage from the Compustat data base, mnemonic icbt.
[g]Of the 396 firms, 37.1 percent reported some form of debt rating on the Compustat data base, of which 77.6 percent was above investment grade. If the senior debt rating was not available on the Compustat data base, the commercial paper rating was used.

casts. The blends can vary over time and over industries. Working models also may include additional explanatory variables, measures of leverage, for example, representing potential determinants of capital spending that do not appear explicitly in any of the four basic models. In any case, the models examined here are often the foundation upon which other models are built and, as such, they are a standard against which potential improvements can be judged.

Description of the Data

This study estimates the basic models of investment for each of 396 corporations selected from COMPUSTAT (see Appendix I for complete descriptions of the data and the analysis). COMPUSTAT contains financial information for more than 14,000 U.S. and Canadian companies, both active and inactive, which have either debt or equity traded publicly. This study considered only domestic manufacturing corporations that reported data continually from 1973 to 1992 without any significant changes in accounting practices. The companies selected represent 51.1 percent of the total assets of active, domestic manufacturing companies recorded by COMPUSTAT in 1992.

The data for COMPUSTAT are taken from reports filed with the Securities and Exchange Commission as well as from company reports and contacts. COMPUSTAT uses these accounting data to create financial statements that are more likely to comprise the same concepts for all firms.[3] This study adjusts some of these data to constant (1987) dollars, as described in Appendix I.

The companies constituting the sample are diverse (Table 2). They range from large, familiar enterprises, such as General Motors and Exxon, to small companies whose sales were less than $1 million in 1992. Some grew continuously throughout the two decades of this study, while the assets, sales, and

[3] See internal memo produced by Compustat titled "Why Compustat?" as well as Zivney and Marcus (1989).

profits of others fell steadily. The capital spending of these companies also varied considerably. Some invested consistently, while the expenditures for others, apart from a few exceptional years, were quite small.

The Performance of the Models

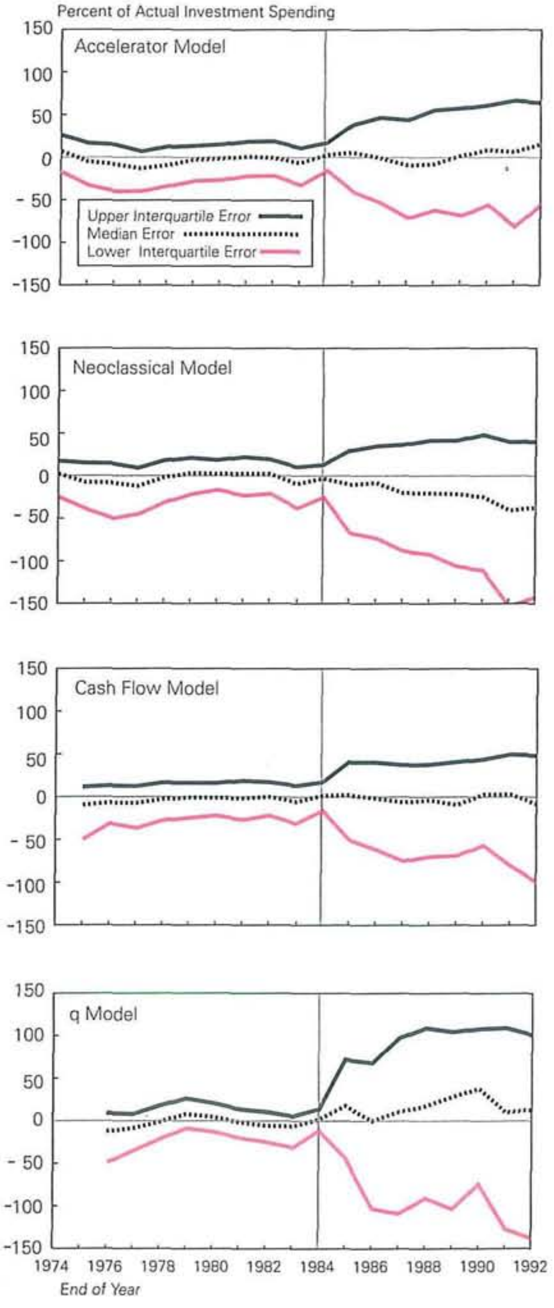
Figure 1 summarizes the ability of the four models to fit and forecast the investment spending of the corporations in this sample. Because the magnitude of the median errors is fairly low, especially for the accelerator and cash flow models, the evidence in these charts suggests that these models describe the trend in capital spending for this sample of corporations fairly well. During the period of estimation, extending from the early 1970s through 1984, the magnitude of the median error in each year averaged less than 6 percent of investment for each of the four models. The magnitude of the median errors during the forecast period, from 1985 through 1992, averaged less than 7 percent of investment for the accelerator and cash flow models. The q model tended to underpredict investment—actual spending exceeded its forecasts—and the magnitude of its median errors averaged about 17 percent of investment. The neoclassical model tended to overpredict investment by about 23 percent of spending.

The dispersion of errors in each year was substantial, indicating that these models lack other variables needed to explain satisfactorily the capital spending for any specific corporation. During the estimation period, the interquartile ranges of errors[4] in the four charts show that the magnitude of the errors often was as great as 25 percent of investment spending for many corporations. During the forecast period, the magnitude of the errors could be at least twice as great.

This substantial dispersion of errors does not necessarily imply that the basic models are a poor foundation for building more customized equations that might represent each corporation's capital spending more accurately. That the demand for capital, on average, should correspond with sales, profits, or the cost of capital seems compelling. Indeed, as noted above, these models describe the trend in capital spending for this group of corporations fairly well despite the considerable changes in business

Figure 1

Forecast Errors of Investment Spending by the 396 Sample Corporations



[4] An interquartile range contains one-half of the errors. The upper line evenly divides the errors above the median; the lower line evenly divides the errors below the median.

conditions during the past two decades. But, the capital spending of emerging enterprises or mature corporations undertaking a major rebuilding may correspond poorly with forecasts that depend only on recent sales, profits, and costs of capital. Capital spending for waning enterprises also may correspond poorly with these basic determinants of investment. Though they may do well for the average corporation, these four models are too general to do well for each corporation.

Models describe best the behavior of the average member of a group, not the behaviors of each constituent.

Nevertheless, the dispersion of errors probably would remain substantial even for the best of models.[5] A company's capital spending can be comparatively "lumpy," varying from modest expenditures one year to substantial expenditures the next; whereas all standard models tend to project a relatively smooth course for capital spending. Models describe best the behavior of the average member of a group, not the behaviors of each constituent. For example, although theory may describe accurately the state of the average molecule in a volume of gas, the state of any specific molecule cannot be predicted very accurately. Similarly, actuaries and doctors may be able to predict the health of large groups of people accurately, but, even with the benefit of very detailed information about one's history and habits, the best models cannot include sufficient information to predict accurately the health of any specific person. However important the universal elements of sales, profits, and the cost of capital may be for determining the general course of investment spending, much of any enterprise's capital budget in a particular year depends on the unique outlook of its managers and on details specific to each enterprise.

Estimating the Models

Each of the four basic models was estimated for each of the 396 corporations from the early 1970s through 1984. Just as the companies were not combined according to their industries, their leverage, their size, or other commonly mentioned characteristics, the coefficients in one company's statistical equations were not constrained to resemble those of another, because the results indicate that the statistical models for the companies constituting these potential groupings can be very dissimilar. For each of the four models, the equations for all companies are constrained only to have the same number of lags.

The charts in Figure 2 show, for each of the four models, the variances of the errors and the sum of the coefficients (the b's in Table 1) for output, cash flow, or the market value for each of the corporations. The charts for the more successful models have more of their points concentrated near the horizontal axis. The vertical scale in these charts represents the proportion of the variance of investment spending that each model fails to explain during the period of estimation. If, for example, the accelerator model explains almost all of the variance of a corporation's investment, that corporation would be represented by a dot near the bottom of the first chart. If, in addition, the sum of the coefficients on the terms measuring output in the accelerator model for this corporation were 0.2, the dot would appear just above this point on the horizontal scale.

The horizontal axes in the second through fourth charts of the figure are scaled to correspond with the horizontal axis in the first chart. For example, cash flow is only about one-tenth of sales, on average, for this sample of corporations. Accordingly, the sums of the coefficients in the cash flow model may tend to be 10 times greater than the sums for the accelerator model.[6] Therefore, the horizontal scale for the cash flow models is 10 times that of the accelerator models. The other two charts are scaled analogously.

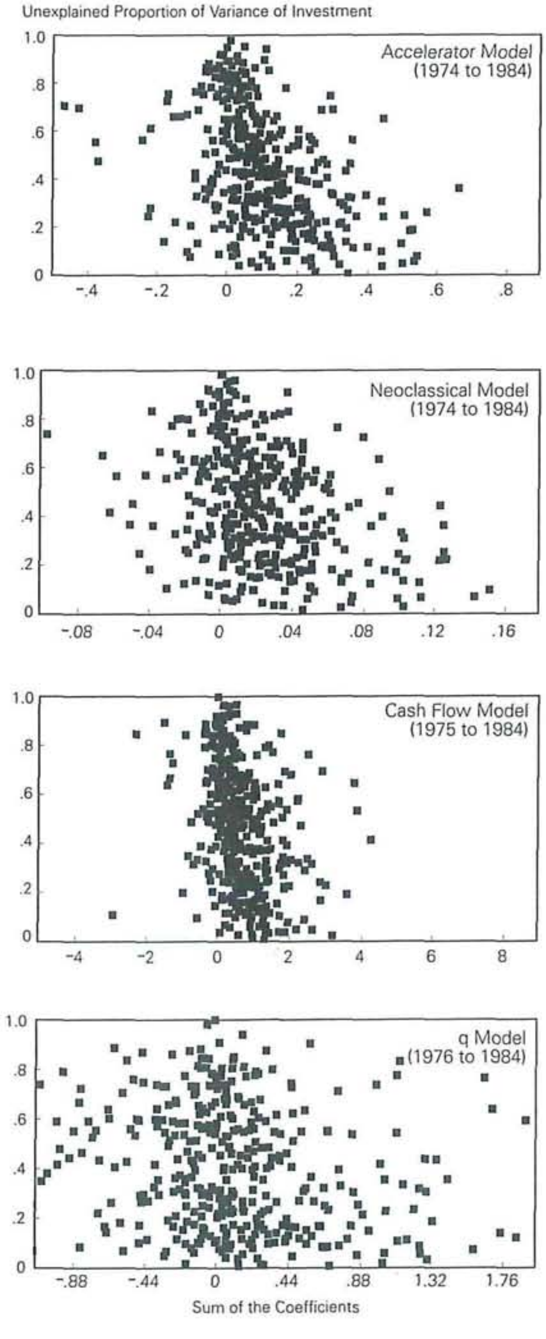
Figure 2 shows that the accelerator, neoclassical, and cash flow models explain the investment spending of most of the corporations in this sample rather well during the period of estimation. The variance of the errors of these models is relatively low for most corporations, and the sums of their coefficients are reasonable. In all three cases, the models explained

[5] See, for example, the results of the studies cited in footnote 2.

[6] If cash flow were a linear function of sales (perhaps including an error term not correlated with investment), and if the coefficient on sales in this function were 0.1, then this predicted relative scaling of coefficients would be fairly accurate. If, however, the relationship were not linear (or any error term in this function were correlated with investment), then the relative scaling could differ significantly from 10. In this sample, the standard deviation of cash flow is also about one-tenth the standard deviation of sales, as would be implied by a linear, nearly homogeneous relationship between cash flow and sales.

Figure 2

Variance of the Errors and Sum of the Coefficients for Each of the 396 Sample Corporations during the Period of Estimation



more than one-half the variance in investment spending for more than one-half of the corporations (see Appendix I for more details). The accelerator and neoclassical models, both of which rely on sales, explain over 40 percent of the variance of investment for more than 70 percent of the corporations. For all three models, the sum of the coefficients is positive for approximately 80 percent of the corporations. This degree of success is remarkable for panel studies.

The charts show only a weak relationship between the residual variance of investment and the sum of the coefficients. Although one might expect to find that the sum of coefficients tended to be greatest when the residual variance was least, a successful fit need not have a large sum. For example, a comparatively low sum would accompany a good fit for corporations with lower capital-to-sales ratios. This is one reason for the horizontal dispersion of points in the charts. For rapidly growing enterprises or for shrinking corporations, the sum of the coefficients can be zero or even negative, because their spending often follows a trend that is correlated best with the size of their stock of capital.

The q model did not fare as well as the other three. The points in its chart are a relatively diffuse cloud. Although the proportion of investment explained by the q model is comparable to that of the other models, the sum of the coefficients is negative for more than 40 percent of the corporations. Furthermore, the incidence of negative sums does not vary greatly with the model's ability to fit the data: The points to the left of zero are essentially as numerous in the lower regions of the chart as they are in the upper regions. These results suggest that the q, in the form used here, may perform best when combined with other determinants of investment spending.[7]

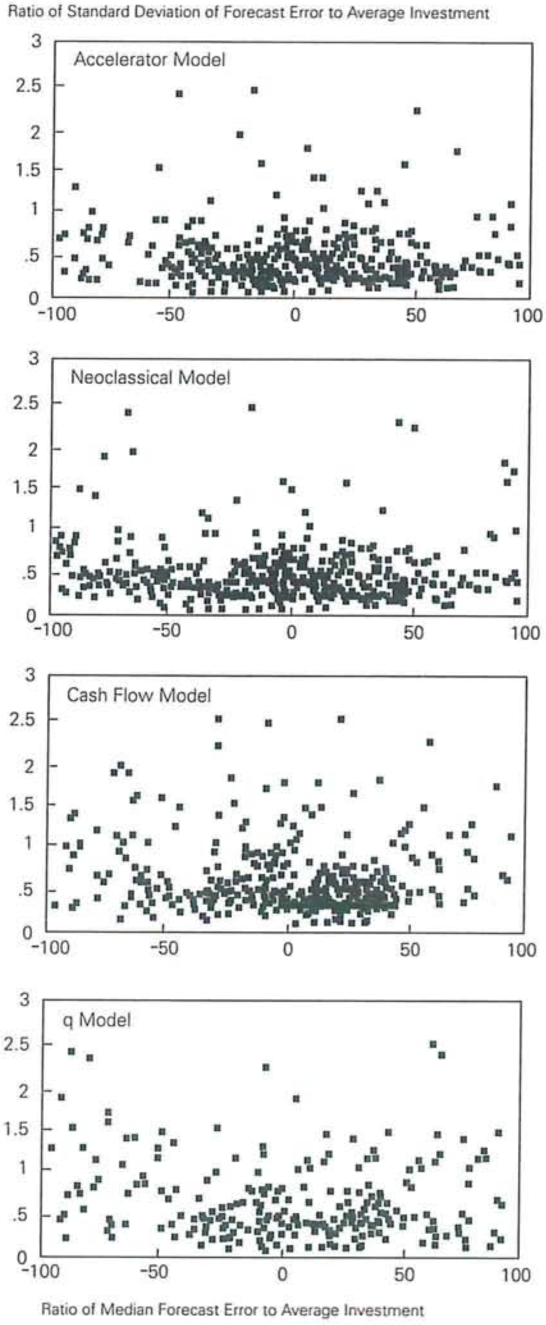
Forecasting with the Models

Figure 3 describes, for each of the models, the variances of errors during the forecast period and the median forecast error for each of the 396 corporations (tables describing these distributions appear in Appendix I). The charts for the more successful models have more of their points concentrated closer to zero on the horizontal axis. The vertical scale represents the ratio of the standard deviation of the forecast error to the average investment for each company.

[7] The difficulties with the q model, no doubt, arise because q is difficult to measure (Klock, Thies, and Baum 1991); furthermore, marginal q, either in place of or in addition to average q, may be an important determinant of investment spending (Kopcke 1993).

Figure 3

Variance of the Errors and the Median Forecast Error for Each of the 396 Sample Corporations during the Forecast Period, 1985 to 1992



The horizontal scale represents the ratio of the median forecast error to the average investment during the forecast period. Accordingly, if the standard deviation of a corporation's forecast error were negligible and its median forecast error were zero, then this corporation would be represented by a point just above zero on the horizontal axis.

The points are dispersed over wide ranges in each of the four charts in Figure 3. Not only, as noted before, can the median errors be substantial relative to investment, but the standard deviations of errors also are very great for many corporations.[8] Nevertheless, these results are reasonably successful for a panel study.

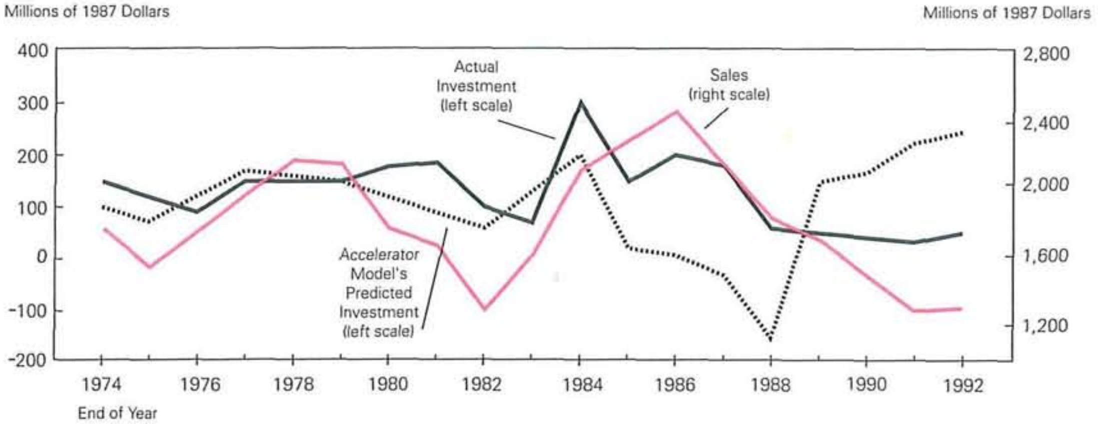
The forecast errors for the accelerator, neoclassical and cash flow models tend to be smaller than those for the q model. Compared to the chart for the q model, the points in the other three charts tend to cluster somewhat closer to zero on the horizontal axis, implying that the standard deviations and median errors are smaller for these three models. The median forecast error is less than 20 percent of investment for about one-quarter of the companies during the forecast interval for the accelerator, neoclassical, and cash flow models. The standard deviation of forecast errors is less than 50 percent of average investment for two-fifths of the companies, and less than 75 percent of investment for two-thirds of the companies. For the q model, the median forecast error is less than 20 percent of investment for only one-seventh of the companies. The standard deviation of errors is less than 50 percent of average investment for only one-quarter of the companies, and less than 75 percent of investment for less than one-half of the companies.

Although substantial errors indicate that a specific statistical equation failed to describe a corporation's capital spending very accurately, these large errors do not necessarily discredit the general theory behind the equation. Many of the points nearest the top of the chart for the accelerator model represent small companies that failed to accomplish their great leap forward: They made comparatively great investments while their sales either remained near or fell to very low rates. For these companies, recent sales

[8] None of the charts show a strong relationship between the standard deviation and the median error. If these charts had used the root mean squared forecast error instead of the standard deviation of forecast errors, then the points in the charts would tend to be higher, the further they were from zero on the horizontal axis. Forecasts with greater average errors typically have greater mean squared errors, because mean squared errors equal the average error squared plus the variance.

Figure 4

Actual and Predicted Investment Spending of USG Corporation



understated management's expectation of future sales, and any model was prone to fail without directly taking these expectations into account. The forecast errors for other companies also could be substantial even though the course of their investment resembled that of their sales after 1984. For example, the median error for USG Corporation was 40 percent of average investment, and the standard deviation of its forecast error was about 1.6 times average investment. Nevertheless, the pattern of USG's investment spending corresponded much more closely to the pattern of USG's sales than these errors suggest (Figure 4). From 1974 to 1992, sales and investment generally rose and fell in concert. Between 1974 and 1984, however, the estimated equation fit investment best by placing a relatively great negative weight on the lagged stock of capital.[9] Consequently, when USG's stock of capital rose considerably in 1985 and 1986 as a result of its rising sales and investment, the equation's forecast of investment fell. When the stock of capital fell after 1987 as its sales and investment fell, the equation's forecast rose.

II. Analysis of Forecast Errors

For all four models of investment, the substantial dispersion of errors in both the estimation and the forecast periods invites further work. This section investigates whether the size of these errors can be reduced by combining the information in the four models or by adding additional variables representing the leverage, size, growth, or industrial classification of the companies in this sample.

The following results suggest that, despite the differences in their explanatory variables, the accelerator, neoclassical, cash flow, and q models contain much the same type of information about the investment spending of the corporations in this sample. The companies for which the accelerator model works best tend to be the same companies for which each of the other models works best. The results also suggest that, once sales, profits, and the cost of capital are taken into account, other general explan-

[9] The estimated equation for USG's accelerator model is:

$$I_t = 824.3 + .119\ Q_t - .059\ Q_{t-1} - .633\ K_{t-1}.$$

The coefficient on the lagged stock of capital reflects two forces. The first tends to make the coefficient negative: More sales entail a greater demand for capital, but the greater is the existing capacity (K_{t-1}), the less new investment is warranted. The faster the company adjusts its capacity to changes in sales, the more negative is the coefficient. The second force tends to make the coefficient positive: The greater is existing capacity, the greater is a company's new investment for the purpose of replacing decaying and obsolete capital. The faster the rate of obsolescence, the greater is the coefficient. Compared to the experience of the forecast period, the data in the estimation period put too much weight on the first force.

Table 3
Results of Comparison of Neoclassical and Accelerator Models for the 396 Firms

1. Percent of Firms in the Same Relative Ranking according to the Standard Deviation of the Forecast Errors/Average Investment (as a percent of all firms)

		Neoclassical Highest 33%	Neoclassical Mid 33%	Neoclassical Lowest 33%
Accelerator	Highest 33%	81.1	16.7	2.3
Accelerator	Mid 33%	12.1	66.7	21.2
Accelerator	Lowest 33%	6.8	16.7	76.5

2. Percent of Firms for Which the Standard Deviation of the Forecast Errors/Average Investment Is Lower for the Neoclassical Model (as a percent of all firms)

		Neoclassical Highest 33%	Neoclassical Mid 33%	Neoclassical Lowest 33%
Accelerator	Highest 33%	8.3	5.6	.8
Accelerator	Mid 33%	.0	7.8	7.1
Accelerator	Lowest 33%	.0	.0	9.8

3. Percent of Firms in the Same Relative Ranking according to the Absolute Value of the Median Forecast Errors/Average Investment (as a percent of all firms)

		Neoclassical Highest 33%	Neoclassical Mid 33%	Neoclassical Lowest 33%
Accelerator	Highest 33%	75.0	18.9	6.1
Accelerator	Mid 33%	17.4	40.2	42.4
Accelerator	Lowest 33%	7.6	40.9	51.5

4. Percent of Firms for Which the Absolute Value of the Median Forecast Errors/Average Investment Is Lower for the Neoclassical Model (as a percent of all firms)

		Neoclassical Highest 33%	Neoclassical Mid 33%	Neoclassical Lowest 33%
Accelerator	Highest 33%	28.8	17.4	6.1
Accelerator	Mid 33%	.0	15.2	42.4
Accelerator	Lowest 33%	.0	.0	23.5

atory variables, such as the burden of debt, do not explain the pattern of errors made by the four basic models.[10] The models do not tend to overstate investment more often for companies with greater-than-average leverage. The distribution of error statistics for companies with substantial debt resembles closely the distribution of error statistics for all companies. Analogous results obtain for companies with relatively little debt.

Comparing the Information in the Models

Tables 3 through 5 compare the structures of the errors of the statistical models. The top panel of Table 3 partitions the sample of 396 corporations into thirds (the three rows): those for which the standard deviation of forecast errors from the accelerator model were highest, average, or lowest. The table then subdivides each third (the three columns) into those corporations for which the standard deviation of forecast errors was relatively great, average, or small using the neoclassical model.

The top panels of the three tables show that the rough ranking of companies by the relative sizes of the standard deviations of their forecast errors is much the same for the four models. In Table 3, for example, of those companies with the greatest standard deviations for the accelerator model (the first

[10] In contrast to these results, a study by Ofek (1993) as well as some of the papers cited in footnote 2 find evidence that greater leverage reduces the demand for investment in some circumstances. Nevertheless, the burden of debt is not absolute; the gravity of debt may be weighed only in the context of prevailing or anticipated business conditions (Kopcke 1989).

Table 4
Results of Comparison of Cash Flow and Accelerator Models for the 396 Firms

1. Percent of Firms in the Same Relative Ranking according to the Standard Deviation of the Forecast Errors/Average Investment (as a percent of all firms)

		Cash Flow Highest 33%	Cash Flow Mid 33%	Cash Flow Lowest 33%
Accelerator	Highest 33%	61.4	31.8	6.8
Accelerator	Mid 33%	29.5	43.9	26.5
Accelerator	Lowest 33%	9.8	23.5	66.7

2. Percent of Firms for Which the Standard Deviation of the Forecast Errors/Average Investment Is Lower for the Cash Flow Model (as a percent of all firms)

		Cash Flow Highest 33%	Cash Flow Mid 33%	Cash Flow Lowest 33%
Accelerator	Highest 33%	18.9	28.8	6.8
Accelerator	Mid 33%	.8	14.4	26.5
Accelerator	Lowest 33%	.0	.0	25.8

3. Percent of Firms in the Same Relative Ranking according to the Absolute Value of the Median Forecast Errors/Average Investment (as a percent of all firms)

		Cash Flow Highest 33%	Cash Flow Mid 33%	Cash Flow Lowest 33%
Accelerator	Highest 33%	55.3	22.0	22.7
Accelerator	Mid 33%	24.2	40.2	35.6
Accelerator	Lowest 33%	20.5	37.9	41.7

4. Percent of Firms for Which the Absolute Value of the Median Forecast Errors/Average Investment Is Lower for the Cash Flow Model (as a percent of all firms)

		Cash Flow Highest 33%	Cash Flow Mid 33%	Cash Flow Lowest 33%
Accelerator	Highest 33%	34.1	22.0	22.7
Accelerator	Mid 33%	.0	26.5	35.6
Accelerator	Lowest 33%	.0	.8	22.7

row of the top panel): 81.1 percent also were among those companies that had the highest standard deviations for the neoclassical model; 16.7 percent were among those with average standard deviations; and 2.3 percent were among those with the smallest. About three-quarters of the corporations, when ranked by the sizes of the standard deviation of their forecast error, are classified the same for the accelerator and the neoclassical models, as shown by the entries along the diagonal of this panel. Moreover, for those corporations whose ranking changes between models, the panel shows no strong evidence that those with the greatest errors for the accelerator model (the first row) are promoted any differently than those with the greatest errors for the neoclassical model (the first column). In other words, this matrix tends to be symmetric with a relatively dominant diagonal.[11] The upper panels of Tables 4 and 5 support similar conclusions comparing the accelerator model to the cash flow and q models. For these two tables, however, corporations ranked as having average errors according to one model are more likely to be reclassified according to the other model, with the number of companies moving up a rank nearly matching the number moving down a rank.

The second panel of the tables shows that the standard deviation of forecast errors tends to be least for the accelerator model. In the second panel of Table 3, for example, only 9.8 percent of the companies with the smallest standard deviation according

[11] Only four of the matrix's nine entries may be chosen (somewhat) independently, because each row and column must sum to one.

Table 5
Results of Comparison of q Model and Accelerator Models for the 396 Firms

1. Percent of Firms in the Same Relative Ranking according to the Standard Deviation of the Forecast Errors/Average Investment (as a percent of all firms)

		q Model Highest 33%	q Model Mid 33%	q Model Lowest 33%
Accelerator	Highest 33%	59.1	31.1	9.8
Accelerator	Mid 33%	25.8	42.4	31.8
Accelerator	Lowest 33%	15.2	26.5	58.3

2. Percent of Firms for Which the Standard Deviation of the Forecast Errors/Average Investment Is Lower for the q Model (as a percent of all firms)

		q Model Highest 33%	q Model Mid 33%	q Model Lowest 33%
Accelerator	Highest 33%	2.3	5.6	3.3
Accelerator	Mid 33%	.0	.5	7.6
Accelerator	Lowest 33%	.0	.0	3.3

3. Percent of Firms in the Same Relative Ranking according to the Absolute Value of the Median Forecast Errors/Average Investment (as a percent of all firms)

		q Model Highest 33%	q Model Mid 33%	q Model Lowest 33%
Accelerator	Highest 33%	52.3	27.3	20.5
Accelerator	Mid 33%	28.0	34.8	37.1
Accelerator	Lowest 33%	19.7	37.9	42.4

4. Percent of Firms for Which the Absolute Value of the Median Forecast Errors/Average Investment Is Lower for the q Model (as a percent of all firms)

		q Model Highest 33%	q Model Mid 33%	q Model Lowest 33%
Accelerator	Highest 33%	9.1	22.7	20.5
Accelerator	Mid 33%	.0	.8	29.5
Accelerator	Lowest 33%	.0	.0	12.1

to the accelerator model had smaller standard deviations according to the neoclassical model. Of those with the greatest standard deviations according to the accelerator model only 14.7 percent had lower standard deviations according to the neoclassical model (the sum of the entries in the first row). The cash flow model performs best against the accelerator model in this respect. In Table 4, just over half of the companies with the greatest standard deviations according to the accelerator model had lower standard deviations according to the cash flow model, and the cash flow model reduced the standard deviations for just over 40 percent of the companies ranked average by the accelerator model.

The median errors tend to be the smallest for the cash flow model. The diagonal entries in the third panel of the tables generally are significantly smaller than their counterparts in the first panel; moreover, the entries in the fourth panel tend to be very much greater than their counterparts in the second panel. These observations are most pronounced in Table 4. Consequently, the cash flow model tended to reduce the median forecast error for three-quarters of the companies for which the median errors were greatest according to the accelerator model (the sum of the entries in the first row), and the cash flow model reduced the median error for three-fifths of the companies with average errors (the sum of the second row). But, the cash flow model reduced the median error for only about one-quarter of the companies with the lowest error according to the accelerator model. The neoclassical model (Table 3) also reduced the median forecast error for more than one-half of the companies with great or average errors according to the accelerator model, and it too reduced the median error for only about one-quarter of the companies with the lowest error according to the accelerator model.

These results do not indicate that any of the four models is better than the rest. This conclusion is supported by comparing each model's forecast errors with the forecasts of the other models (see Appendix II). For most of the companies, the forecasts of one model do not dominate the forecasts of another model. Each of the models, however, does appear to forecast the capital spending better than the other models for a small subset of the companies.

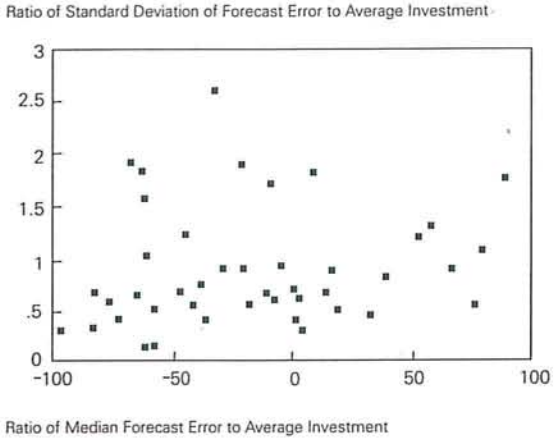
Although the results indicate that the four models contain much the same information, they also might seem to suggest that the cash flow model might be most suitable for those companies whose median forecast errors were relatively great according to the accelerator model (Table 4, the first rows of panels 2 and 4). This possibility is important because, due to imperfections in credit markets, some companies might be constrained by their cash flow from investing as much as warranted by their other "fundamentals."

Further analysis of the evidence, however, suggests that cash constraints do not explain the accelerator model's errors. Instead, the results simply imply that the cash flow model's median errors for each company are not correlated very greatly with those of the accelerator model. Consequently, for those companies for which the median error is smaller than average according to the accelerator model, the median error of the cash flow model tends to be greater. Conversely, when the accelerator model's median errors are greater than average, the median error of the cash flow model often is smaller.

The characteristics of the corporations with comparatively large median errors according to the accelerator model are not consistent with cash flow constraints. Of the 132 companies with the greatest median forecast errors for the accelerator model, for 60 companies this model tended to underpredict investment—capital spending exceeded the forecast. Figure 5 shows the cash flow model's error statistics for the remaining 72 companies, for which the accelerator model overpredicted investment spending. If the cash flow of these companies restricted their capital spending, their median errors should be comparatively small or positive according to the cash flow model. Conversely, large negative errors would indicate that their spending was "slack" compared to their cash flow. As shown in the chart, their error statistics are distributed much like those of all 396 corporations (the third panel of Figure 3), except that the median errors for these 72 companies tend to be more negative than those for the full sample. Many of these 72 companies are large, have investment-grade credit ratings, or have comparatively low leverage. This evidence suggests that the cash flow model does not systematically improve the forecast of investment spending for these companies by detecting binding cash constraints.

Figure 5

Cash Flow Model's Error Statistics during the Forecast Period (1985-1992), for the 72 Companies with Greatest Errors of Overprediction by the Accelerator Model



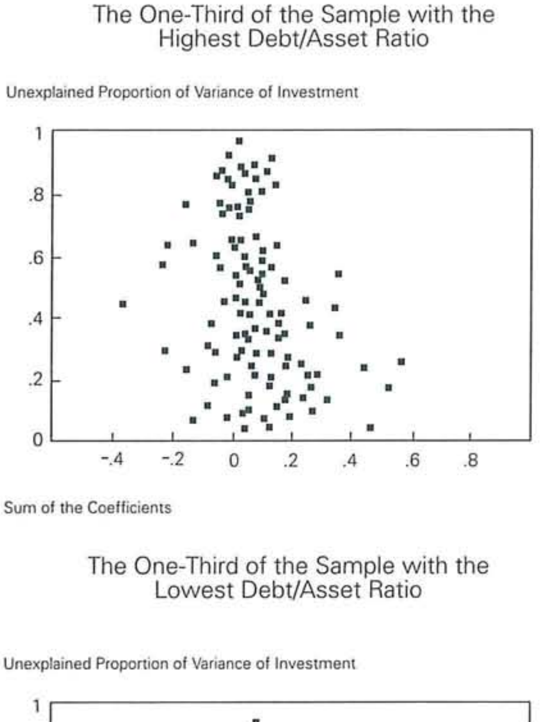
The Contributions of Leverage, Liquidity, Size, Growth, and Industrial Classification

The basic models take no explicit account of the companies' debt burdens, their size, the rate at which they are growing, or their lines of business. This section describes the potential contribution of this additional information by analyzing the correspondence between these new variables and the models' errors.

Companies with similar leverage often are assumed to behave similarly, and companies with very different debt burdens frequently are assumed to behave differently. The evidence in this sample of corporations suggests that the characteristics of capital spending do not depend on leverage. For this

Figure 6

Error Statistics for the Accelerator Model during the Period of Estimation (1974 to 1984) for Subsets of the Sample of Corporations



reason, among others, this study did not estimate investment equations for groups of corporations with comparable leverage, even though they might be in similar lines of business.

The two panels of Figure 6 show the distributions of the error statistics and the sums of coefficients for the accelerator model, taken from the first panel of Figure 2, for the third of the sample (132 corporations) with the greatest ratios of debt to assets (the upper panel) and the third with the lowest ratios (the lower panel). The distributions of points in the two panels neither differ significantly from each other nor differ significantly from the distribution in Figure 2. These results do not change materially by limiting the comparison to companies in comparable industries. Similar results obtain for the other models. Comparable results also obtain when the burden of debt is measured by the ratio of income before interest expense and taxes to interest expense (the coverage ratio) or by the change in either the ratio of debt to assets or the coverage ratio.

This study also finds that the models' errors for companies with similar leverage tend not to resemble one another. The two panels of Figure 7 show the error statistics for the accelerator model (taken from the first panel of Figure 3) for those 132 corporations with the greatest ratios of debt to assets (the upper panel) and those with the lowest ratios (the lower panel). If substantial leverage, as measured by the debt-to-asset ratio, tended to depress investment beginning in the late 1980s, then the model should tend to overpredict investment for companies with substantial leverage, and points in the first panel should tend to be displaced more to the left than the points in the other panel. Instead, the distributions of points in both of the panels closely resemble each other as well as the distribution of points in Figure 3.[12] Similar results obtain for the distributions of error statistics from the other three models. Comparable results also obtain for the coverage ratio.

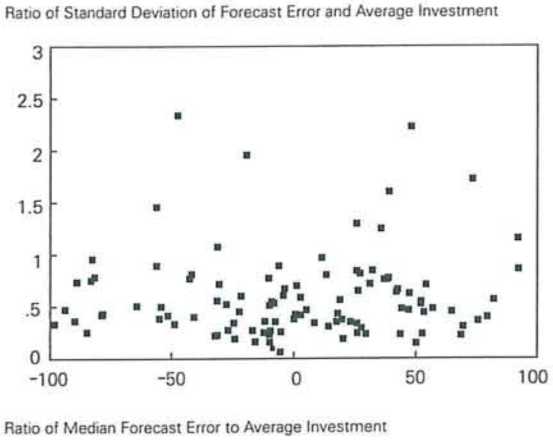
The patterns of the annual errors behind the summary statistics depicted in Figure 6 also suggest that the forecast errors are not similar for companies with comparable debt burdens. The number of positive covariances in the variance matrix of the forecast errors for the 132 corporations appearing in the first panel essentially matched the number of negative covariances, and their pattern corresponded to no simple subgroupings of companies. The forecast errors for company A, for example, may be positively correlated with those of B and C, but B's errors often are negatively correlated with those of C, and so forth. This lack of evident subgroupings also is evident from the principal components of these forecast errors. Many eigen vectors are required to describe

[12] Formal chi-square goodness-of-fit tests do not reject the similarity of these distributions.

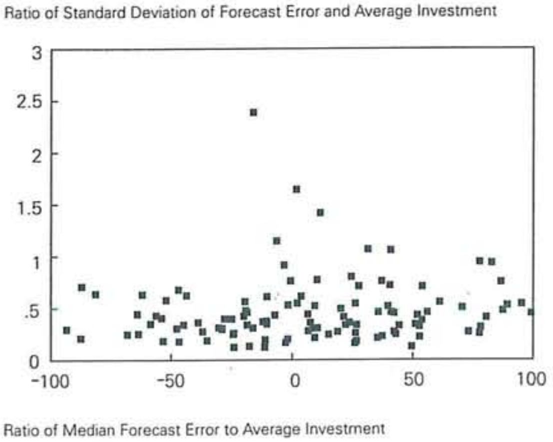
Figure 7

Error Statistics for the Accelerator Model during the Forecast Period (1985 to 1992) for Subsets of the Sample of Corporations

The One-Third of the Sample with the Highest Debt/Asset Ratio



The One-Third of the Sample with the Lowest Debt/Asset Ratio



the structure of the variance matrix, and the structure of each vector is complex. The maximal eigen value of the matrix was only 50 percent greater than the fifth-largest eigen value, and three times greater than the tenth-largest eigen value. The coefficients in the eigen vectors did not weight the companies in a consistent fashion: The coefficients across companies within a vector and for a company across the vectors ranged from substantial positive values to substantial negative values. Again, similar results obtained for both the other models and the other measures of the burden of debt.

This study also compared the distributions of forecast errors to other characteristics of the companies constituting this sample. Analyses similar to the foregoing showed that the pattern of errors bore little resemblance to the ratios of short-term debt to assets, variance of cash flows, dividend payment rates, rates of growth, or sizes of these corporations. Altogether, these results imply that the structure of the basic models' errors does not correspond very closely to common measures of leverage and liquidity.

III. Conclusion

The capital spending of businesses appears to correspond with their sales, profit, and cost of capital little differently today than a decade ago. According to this study of 396 corporations, the average company's investment in each year differs remarkably little from forecasts derived from these basic measures of business conditions. This conclusion, arising from the analysis of distinct corporations, is similar to the finding of a previous study that examined the aggregate investment of businesses (Kopcke 1993).

The capital spending of many of the companies in this study's sample, however, corresponds very poorly with their sales, profits, or cost of capital. These divergences suggest that sales, profits, and the cost of capital do not represent fully an enterprise's particular incentives for investing. Unfortunately, the missing elements seem to be idiosyncratic and difficult to specify. The other influences that account for this dispersion in capital spending might include the leverage, size, or industrial classification of each corporation. Nevertheless, once sales have been taken into account, differences in leverage, for example, do not distinguish companies spending more than predicted by their sales from those spending less. For this sample of corporations, the pattern of average forecast errors derived from the statistical models using sales, cash flow, and the cost of capital does not correspond very closely to measures of indebtedness, liquidity, size, or type of business.

Companies with comparable liquidity or debt burdens do not tend to behave similarly. Not only does the distribution of average forecast errors correspond poorly with leverage, but also the covariances among forecast errors for companies with comparable leverage are not similar. For example, the forecast errors for companies with substantial leverage tend to change neither in concert nor in simple patterns. Consequently, these findings do not support generalizations contending that companies with more debt are investing less than their sales and cash flows would warrant.

Similar to the conclusion from many studies of the returns on securities, this article finds that investment appears to depend on no more than a few macroeconomic "factors," which seem to be represented adequately by sales and cash flows in common investment equations. This connection between capital markets and capital spending, which is most evident in the q model, also is very much in the spirit of the other models of investment used in this study. If capital formation has been disappointingly weak recently, the unusually slow growth of economic activity undeniably bears much of the responsibility.

Perhaps it is not surprising that leverage, liquidity, and other variables should influence capital spending so little once the general business climate (represented by sales or cash flow) has been taken into account. The choice of leverage, like capital spending, depends on the prospect for profit. A good business climate can foster both investment and debt financing. In these cases, higher leverage does not deter investment; instead, it may appear to facilitate investment. At other times, companies may increase their leverage while they reduce their capital spending, if the return on existing capital is great compared to that foreseen on new investments. In these cases, higher leverage may appear to deter investment. In any of these cases, appearances can be deceiving, because investment and leverage jointly depend on business conditions, and this dependency entails no consistent relationship between indebtedness and investment.

For the making of economic policy, the evidence suggests that the familiar macroeconomic incentives for investment would be no less effective today than they have been in the past. In particular, the volume of investment spending would appear to respond to monetary and fiscal policies in the customary way. This is clearest, of course, for the neoclassical, cash flow, and q models. The success of the cash flow model, for example, implies that the taxation of businesses' income and the cost of financing investments ought to influence capital budgets: Profits and cash flow might increase as a result of either rising sales or a tax cut. But, even for the accelerator model, which lacks an explicit reference to interest rates, policies can affect capital spending by altering the composition or volume of output. Despite their potential differences, the models agree, however, that monetary or fiscal policy must be unusually aggressive to increase investment spending substantially when the rate of growth of GDP is unusually low.

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Appendix I: Methodology, Definitions and Data

Firm data are taken from COMPUSTAT, and are expressed in annual terms. Only U.S. manufacturing firms were evaluated. Firms were eliminated if a significant change in accounting practices occurred during the time period of the study (1973 to 1992) or if the data were not continuous for the entire period. This resulted in a sample of 396 firms. In the following description of the construction of individual variables, the COMPUSTAT mnemonic follows the definition, stated in parentheses in lower case.

Investment: Capital expenditures for the construction and acquisition of property, plant, and equipment, which includes the property, plant, and equipment of acquired companies (capxv). These COMPUSTAT data are adjusted to constant 1987 dollars from book value using data from the U.S. Bureau of Economic Analysis (BEA). The BEA releases data for historical (book) value of investment as well as constant (1987) dollar value, which are classified by 2-digit SIC codes. Thus, it is possible to estimate the constant dollar measure of investment from a given book value, by industry.

KS: Property, plant and equipment, less accumulated depreciation (ppent). The BEA releases historical (book) and constant dollar data for capital stock, which are used in the same manner as in the investment data.

Cash flow: Cash before extraordinary items (ibc) plus depreciation and amortization (dpc). These data are divided by the same investment deflators as above, using the same 2-digit SIC breakdown.

Real sales: nominal sales (sale) were divided by the Consumer Price Index, released by the U.S. Bureau of Labor Statistics.

The user cost of capital is the percent of total investment that went toward equipment of nonfinancial corporate business, measured by the BEA, multiplied by the user cost of capital for equipment (denoted as RE) plus the percent of total investment for structures multiplied by the user cost of capital for structures (RS). Quarterly data were averaged to yield annual figures.

$$RE = (CE)(.15 + D)(1 - ITC - TAX*WE)/(1 - TAX)$$

$$RS = (CS)(.05 + D)(1 - TAX*WS)/(1 - TAX)$$

CE, CS: Implicit price deflators for producers' durable equipment and nonresidential structures, released by the BEA.

The annual economic rate of depreciation is estimated at 15 percent for equipment and 5 percent for structures. D, the discount rate for corporate profits after corporate income tax, equals the Standard & Poor's dividend/price ratio for common stocks plus an estimate of the real rate of growth of nonfinancial corporate enterprises, a constant 4 percent.

Both ITC, the investment tax credit for equipment, and TAX, the statutory effective tax rate paid by U.S. corporations, are taken from the DRI Model of the U.S. Economy. ITC is the weighted average of investment tax credits for autos, office equipment, and other equipment.

WE: The present value of depreciation allowances for equipment using the most "accelerated" formula permitted by law. From 1973:I through 1981:II, equipment was depreciated using Sum of the Year's Digits; from 1981:III through 1986:IV, equipment was depreciated using the Accelerated Cost Recovery System; from 1987:I through 1992:IV, the Modified Accelerated Cost Recovery System was used. Tax life for equipment is the weighted average of the tax life for different classes of equipment taken from the DRI Model of the U.S. Economy. The nominal discount rate used equals INFLATN times (1 + 0.015); 0.015 represents the assumed real rate of discount (after taxes).

WS: Similarly defined for structures. Structures were depreciated according to the 150 percent Declining Balance Method for 1973:I to 1981:II; from 1981:III through 1986:IV, buildings were depreciated according to the Accelerated Cost Recovery System; and the Modified Accelerated Cost Recovery System thereafter. The discount rate used equals INFLATN times (1 + 0.015).

INFLATN: Rate of inflation expected over the coming five years. For 1980:IV through 1992:IV, INFLATN is the average of the monthly surveys by Richard Hoey, available from the Board of Governors of the Federal Reserve System, FAME Database. Hoey's survey data were regressed on lagged values of the annual rate of change in the CPI for 1980:IV to 1992:IV. The equation was used to obtain expected inflation for the prior periods.

q: The ratio of the market value of assets, denoted MVK, to the replacement value of those assets, RPL.

MKV= CD + LTD + VCS + VPS.

RPL = CKS + OA.

CD: Debt in current liabilities (dlc).

LTD: Total long-term debt (dltt) divided by the NYSE bond index, which measures market value as a percent of par value for all New York Stock Exchange listed bonds. This series is found in the NYSE *Fact Book*.

VCS: The annual average of the monthly closing prices of common stock (prccm) multiplied by the number of shares outstanding at the end of the year (csho).

VPS: Cash dividends to preferred stockholders (dvp) divided by Standard & Poor's preferred stock yields.

CKS: Net property plant and equipment (ppnet) at replacement value. The BEA releases capital stock data in current dollars, as well as historic and constant dollar values, which were used to adjust property, plant, and equipment.

OA: Total assets (at) minus net property, plant, and equipment (ppnet).

All equations were estimated using ordinary least squares. The regressions for the Accelerator and Neoclassical models were fit from 1974 to 1984, using real sales for the Accelerator model and nominal sales divided by the user cost of capital for the Neoclassical model, lagged one year. Both the Cash Flow and q models were lagged two years. Because of the definition of the q model, it was fit from 1976 to 1984, while the Cash Flow model fit began in 1975. All models were forecasted from 1985 to 1992.

Table A1 summarizes the median errors of all models for both the fit and forecast periods. Tables A2 to A5 give a numerical representation of Figure 2, stating the number of firms whose statistics fall into specified intervals. The fit statistic for Figure 2 is the variance of the error term divided by the variance of investment. Tables A6 to A9 do the same for Figure 3, with the fit statistic the standard deviation of the error term divided by average investment.

Table A1
Median Error for Time Analysis

Model	Mean	Mean Absolute
Fit Period		
Accelerator	−3.27	5.23
Cash Flow	−3.47	3.75
Neoclassical	−2.70	5.02
q Model	−2.46	5.55
Forecast Period		
Accelerator	2.53	6.98
Cash Flow	−2.76	4.67
Neoclassical	−22.96	22.96
q Model	16.87	16.87

Table A2
Accelerator Model
Fit Period, 1974 to 1984

	Sum of the Coefficients															
Fit	<−.5	−.5 to −.4	−.4 to −.3	−.3 to −.2	−.2 to −.1	−.1 to 0	0 to .1	.1 to .2	.2 to .3	.3 to .4	.4 to .5	.5 to .6	.6 to .7	.7 to .8	.8 to .9	Total
0 to .1					2	1	6	4	4	3	2	3				25
.1 to .2					1	2	8	13	12	4	1	3				44
.2 to .3				2	2	4	13	17	13	5	1	2				59
.3 to .4						8	19	14	9	5	1		1			57
.4 to .5	1		1			7	26	15	7	2						59
.5 to .6			1	1		6	23	7	6	1						45
.6 to .7	1	1		1	3	5	19	4	2	1	1					38
.7 to .8		1			2	9	18	1	1							32
.8 to .9						12	16	2								30
.9 to 1						3	3	1								7
Total	2	2	2	4	10	57	151	78	54	21	6	8	1	0	0	

Table A3
Neoclassical Model
Fit Period, 1974 to 1984

	Sum of the Coefficients															
Fit	<−.1	−.1 to −.08	−.08 to −.06	−.06 to −.04	−.04 to −.02	−.02 to 0	0 to .02	.02 to .04	.04 to .06	.06 to .08	.08 to .1	.1 to .12	.12 to .14	.14 to .16	.16 to .18	Total
0 to .1						1	6	5	3	3		3		2		23
.1 to .2					2	3	7	7	9	4	3	2				37
.2 to .3				1		5	13	9	9	2	1	3	3			46
.3 to .4				1	2	7	18	17	11	2	2	2	1			63
.4 to .5	1		1	1		7	16	11	4	4			1			46
.5 to .6				2	2	8	17	19	14	3	1					66
.6 to .7	1		1		3	8	18	9	5		1					46
.7 to .8	1	1			2	6	10	6	1	1	1					29
.8 to .9					2	6	15	5								28
.9 to 1						4	7	1								12
Total	3	1	2	5	13	55	127	89	56	19	9	10	5	2	0	

Table A4
Cash Flow Model
Fit Period, 1975 to 1984

	Sum of the Coefficients															
Fit	>−5	−5 to −4	−4 to −3	−3 to −2	−2 to −1	−1 to 0	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	Total
0 to .1						1	8	10	4	1						24
.1 to .2	1			1		2	24	17	1	1						47
.2 to .3						5	23	12	3							43
.3 to .4						7	20	15	4							46
.4 to .5						3	28	10	1		1					43
.5 to .6						7	30	11	2	1						51
.6 to .7	2				2	11	37	7	2	1						62
.7 to .8					2	6	21	4	1							34
.8 to .9				1	1	9	22	2								35
.9 to 1						2	9									11
Total	3	0	0	2	5	53	222	88	18	4	1	0	0	0	0	

Table A5
q Model
Period of fit, 1976 to 1984

	Sum of the Coefficients																
Fit	<−1.11	−1.11 to −.88	−.88 to −.66	−.66 to −.44	−.44 to −.22	−.22 to 0	0 to .22	.22 to .44	.44 to .66	.66 to .88	.88 to 1.1	1.1 to 1.32	1.32 to 1.54	1.54 to 1.76	1.76 to 1.98	<1.98	Total
0 to .1	2		1	1	2	5	11	5	2	5	3	3		1			41
.1 to .2	3		2	3	4	10	11	10	11	2	1	2	1		2	2	64
.2 to .3	3		1	4	5	8	16	6	2	2	3	1					51
.3 to .4	3	2			4	12	6	4	3	4	1	3	1			2	45
.4 to .5	5	3	2	2	3	6	11	9	2		1	1	1			1	47
.5 to .6	2	1	4	4	8	10	10	6	2	3		1			1	1	53
.6 to .7	2		1	2	4	6	10	5	2					1		2	35
.7 to .8		2	1	3	3	7	9	4	2	1	1	1		1			35
.8 to .9	2			3	1	8	5	1				1					21
.9 to 1						1	2		1								4
Total	22	8	12	22	34	73	91	50	27	17	10	13	3	3	3	8	

Table A6
Accelerator Model
Forecast Period, 1985 to 1992

	Median Error as a Percent of Average Investment												
Fit	<−100	−100 to −80	−80 to −60	−60 to −40	−40 to −20	−20 to 0	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100	>100	Total
0 to .25		2		4	7	12	7	11	7			1	51
.25 to .5	5	7	6	10	22	21	20	19	21	10	6	4	151
.5 to .75	11	5	4	5	6	14	9	10	13	4	6	11	98
.75 to 1	9	5		4	1	3	5	8	1	1	3	5	45
1 to 1.25	3	1			1	1		1	1		1	6	15
1.25 to 1.5	4			1			2	2				1	10
1.5 to 1.75	5					1	1		1	1		1	10
1.75 to 2	3					1							4
2 to 2.25													0
2.25 to 2.5	2			1		1			1				5
2.5 to 2.75	1											1	2
2.75 to 3													0
>3	3										1	1	5
Total	46	20	10	25	37	54	44	51	45	16	17	31	

Percent of Firms with Absolute Errors in a Given Range

<20%	<40%	<60%	<80%	<100%
24.7	47.0	64.6	71.2	80.6

Percent of Firms with the Fit in a Given Range

<.25	<.5	<.75	<1	<1.25	<1.5	<1.75	<2	<2.25	<2.5	<2.75	<3
12.9	51.0	75.8	87.1	90.9	93.4	96.0	97.0	97.0	98.2	98.7	98.7

Table A7
Neoclassical Model
Forecast Period, 1985 to 1992

	Median Error as a Percent of Average Investment												
Fit	<−100	−100 to −80	−80 to −60	−60 to −40	−40 to −20	−20 to 0	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100	>100	Total
0 to .25			1	5	5	11	9	4	2	2			39
.25 to .5	12	8	7	18	18	20	19	19	5	5	4	5	140
.5 to .75	21	7	7	9	8	9	8	9	4	3	3	8	96
.75 to 1	11	5	2	4	2	4	4	8	2	2	3	6	53
1 to 1.25	11				2		1	1	1			5	21
1.25 to 1.5	8	1				1	1	1				2	14
1.5 to 1.75	5	1				1	1	1			1		10
1.75 to 2	1	1	1								2		5
2 to 2.25	1								1				2
2.25 to 2.5	5		1			1		1				1	9
2.5 to 2.75	2												2
2.75 to 3	1											1	2
>3	2											1	3
Total	80	23	19	36	35	47	43	44	15	12	13	29	

Percent of Firms with Absolute Errors in a Given Range

<20%	<40%	<60%	<80%	<100%
22.7	42.7	55.6	63.4	72.5

Percent of Firms with the Fit in a Given Range

<.25	<.5	<.75	<1	<1.25	<1.5	<1.75	<2	<2.25	<2.5	<2.75	<3
9.8	45.2	69.4	82.8	88.1	91.7	94.2	95.5	96.0	98.2	98.7	99.2

Table A8
Cash Flow Model
Forecast Period, 1985 to 1992

	Median Error as a Percent of Average Investment												
Fit	<−100	−100 to −80	−80 to −60	−60 to −40	−40 to −20	−20 to 0	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100	>100	Total
0 to .25			2	3	6	4	7	12	1				35
.25 to .5	5	4	4	4	18	29	25	32	10	4		1	136
.5 to .75	5	2	6	9	8	11	9	12	8	2	2	1	75
.75 to 1	7	3	4	5	3	11	7	7	3	7	1	1	59
1 to 1.25	4	1	3	2		2	3	1	2	3	2	3	26
1.25 to 1.5	9	1		1	1	2	3	1	1	1		1	21
1.5 to 1.75	3		2	1		2		1			1	3	13
1.75 to 2	5		3			1	1	1					11
2 to 2.25	1				1							1	3
2.25 to 2.5	2					1				1			4
2.5 to 2.75	1				1			1					3
2.75 to 3													0
>3	3		2				1			1		3	10
Total	45	11	26	25	38	63	56	68	25	19	6	14	
				Percent of Firms with Absolute Errors in a Given Range									
				<20%	<40%	<60%	<80%	<100%					
				30.1	56.8	69.4	80.8	85.1					
				Percent of Firms with the Fit in a Given Range									
	<.25	<.5	<.75	<1	<1.25	<1.5	<1.75	<2	<2.25	<2.5	<2.75	<3	
	8.8	43.2	62.1	77.0	83.6	88.9	92.2	94.9	95.7	96.7	97.5	97.5	

Table A9
q Model
Forecast Period, 1985 to 1992

	Median Error as a Percent of Average Investment												
Fit	<−100	−100 to −80	−80 to −60	−60 to −40	−40 to −20	−20 to 0	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100	>100	Total
0 to .25					2	3	3	4	1	1			14
.25 to .5	6	2	5	2	8	11	12	11	14	11	4	9	95
.5 to .75	10	2	6	3	7	5	8	5	7	6	8	12	79
.75 to 1	6	2	2	2	2	4	4	1	3	6	3	9	44
1 to 1.25	6	1	2	1		2	2	5	4	2	2	14	41
1.25 to 1.5	7	2	1	4		1	1		1	2	3	5	27
1.5 to 1.75	7		2		1		1	1				6	18
1.75 to 2	6	1										4	11
2 to 2.25	5					1						4	10
2.25 to 2.5	6	2								1		5	14
2.5 to 2.75	3								1			3	7
2.75 to 3	1											3	4
>3	17				1	1				1		12	32
Total	80	12	18	12	21	28	31	27	31	30	20	86	
				Percent of Firms with Absolute Errors in a Given Range									
				<20%	<40%	<60%	<80%	<100%					
				14.9	27.0	37.9	50.0	58.1					
				Percent of Firms with the Fit in a Given Range									
	<.25	<.5	<.75	<1	<1.25	<1.5	<1.75	<2	<2.25	<2.5	<2.75	<3	
	3.5	27.5	47.5	58.6	68.9	75.8	80.3	83.1	85.6	89.1	90.9	91.9	

Appendix II

A test presented in Davidson and MacKinnon (1982) was used to compare the relative performance of the models' forecasts. Consider a blended forecast of investment,

$$I = (1 - \alpha)\hat{I}_1 + \alpha\hat{I}_2 + e$$

where I is actual investment, I_1 and I_2 are forecasts for two different models, and α is a weight chosen to minimize total forecast error. This equation may be rewritten as

$$I - \hat{I}_1 = \alpha(\hat{I}_2 - \hat{I}_1) + e.$$

The Model I_1 forecast error is regressed on the difference between the forecast of an alternative model and the Model I_1 forecast. The regression coefficient is the weight assigned to the alternative model's forecast in order to minimize the total forecast errors. For example, consider the case where the error of the accelerator model is regressed on the difference between the cash flow and the accelerator models' forecasts. If the regression coefficient were zero, the cash flow model's forecast adds no information to that already represented by the accelerator model.

Table A10 summarizes the results of the regressions. Each entry shows the proportion of companies for which the regression coefficient had a significant t-statistic. Beginning with the accelerator model, with a 5 percent significance level, the cash flow model's forecast improves upon the accelerator model's forecast of investment for 33.8 percent of the companies. At a 1 percent significance level, the cash flow model's forecast improves the accelerator model's forecast for 15.7 percent of the companies. The table shows that the accelerator model tends to benefit the least by adding other models' forecasts (reading across the different rows), yet contributes the most to the other forecasts (reading down the columns). The q model clearly benefits the most. Nevertheless, the q model contributes to each of the other forecasts, as seen in the last two columns of Table A10.

The coefficients associated with the significant t-statistics tended to center around 0.8 for the majority of the models, with relatively few greater than 1 or less than 0.2. Figure A1 (on p. 30) shows two examples of the distributions of coefficients significant at the 5 percent level. The values of the coefficients imply that if the t-statistic is significant, the forecast of the model most often is weighted about four times that of the original model in order to minimize the forecast error.

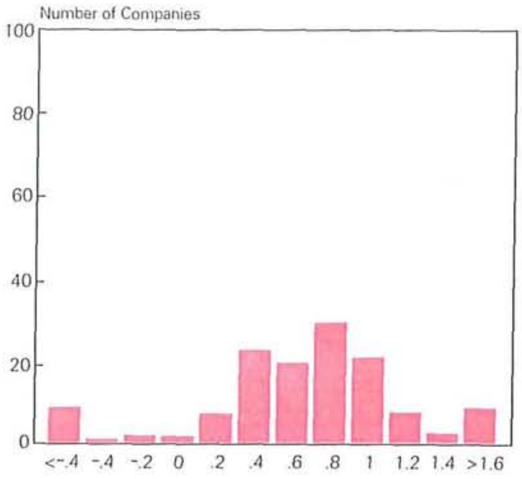
Table A10
Proportion of the Companies for Which the Coefficient for the Difference between Forecasts Is Significantly Different from Zero
Percent of All Firms

	Alternative Model							
	Accelerator		Cash Flow		Neoclassical		q Model	
Original Model	5%	1%	5%	1%	5%	1%	5%	1%
Accelerator			33.8	15.7	31.6	16.9	30.3	15.7
Cash Flow	51.5	32.8			45.7	30.3	37.1	21.7
Neoclassical	43.4	26.0	38.4	21.0			31.6	19.4
q Model	71.5	56.6	62.9	47.0	68.2	52.0		

Figure A1

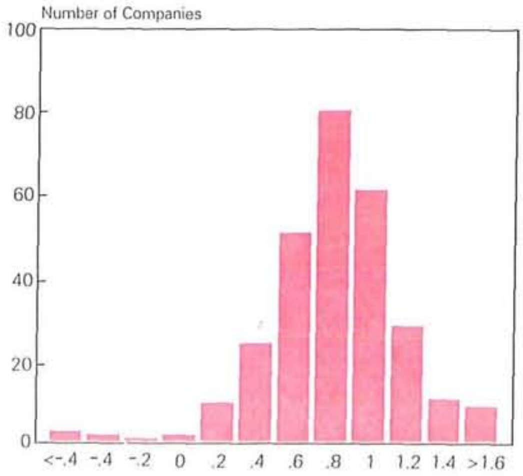
Distribution of the Weights Given to the Alternative Model

Accelerator Model Original and Cash Flow Alternative



Coefficients Significant at the 5 Percent Level

q Model Original and Neoclassical Alternative



Coefficients Significant at the 5 Percent Level