Forecasting Investment with Models and Surveys of Capital Spending

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The investment spending of businesses is one of the most closely watched elements of the national accounts, partly because variations in this capital spending account for much of the variation in national output during business cycles, and partly because future living standards depend on the volume of previous capital formation. Because accurate forecasts of investment are especially valuable for policymakers, the U.S. Department of Commerce has collected surveys of businesses' plans for capital spending for almost half a century. At their inception, these surveys were essential for forecasting investment. In the 1940s and 1950s, statistical forecasting was a nascent art, and national income accounting was only beginning to provide the data required for statistical modelling. Despite the great strides in statistical forecasting during the ensuing decades, the surveys retain considerable appeal because the magnitude of the errors of the models can be uncomfortably large for policymakers.

This article assesses the recent contribution of the Department of Commerce's survey to forecasts of business investment, once other information on business conditions is taken into account. In principle, the survey ought to be valuable. Economic data might reveal much about prevailing business conditions, but the survey can record investors' intentions. The scope of the survey is limited, however, and the relationship between the capital spending of the survey's respondents and the investment spending reported in the national accounts can vary considerably.

Despite its promise, the survey appears to improve forecasts of investment only marginally since the 1970s. For forecasts as short as one quarter, knowing the survey's results is not as valuable as knowing the history of investment spending and the output of businesses. For forecasts of investment over the coming year, the information in the survey is not as useful as that in the history of output, cash flows, costs of capital, and investment itself.

The survey has failed to fulfill its potential since the 1970s mainly because the capital spending of the businesses that respond to the survey has increased significantly relative to the investment spending reported in the national accounts. In the past, when the ratio of the respondents' capital spending to total investment spending was more stable, the survey was a more accurate indicator of businesses' purchases of structures and equipment. If this ratio should become more stable in the future, then the survey might become a more reliable indicator of the aggregrate investment spending of businesses.

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This article's results imply that the rate of growth of investment spending cannot be predicted with great precision. For example, if investment is expected to grow 10 percent from one year to the next, the actual rate of growth could easily be as great as 15 percent or as low as 5 percent. This uncertainty blurs the apparent distinctions among forecasts. It also suggests that policymakers who wish to guarantee a rapid rate of capital formation may need to set their sights very high indeed to be confident of success.

I. The Census Bureau's Surveys of Capital Spending

Forecasts of investment spending by businesses depend not only on projections from statistical models but also on surveys of the capital budgets of businesses, principally that conducted by the U.S. Bureau of the Census. This survey covers expenditures by businesses for new plants and equipment that are to be used in the United States.

These surveys, done quarterly since 1947, collect planned expenditures one, two, and three quarters in advance. In the fourth quarter of each year, the survey also collects planned spending for the ensuing calendar year. The Census Bureau currently collects responses for the quarterly surveys from approximately 5,000 companies; for the annual survey conducted at the end of each year, the Bureau receives responses from approximately 9,300 companies.

The capital spending reported by the survey's respondents does not necessarily correspond to the concept of business investment reported in the national accounts. The Census samples enterprises in manufacturing and in the mining, transportation, public utility, and commercial industries. The quarterly survey does not cover farm enterprises, professional organizations, or real estate operators. The scope of the annual survey is somewhat more comprehensive, covering real estate operators, hospitals, and religious enterprises. The Bureau uses the results of the surveys—adjusted for outliers, seasonal factors, and systematic biases—in conjunction with benchmarks for past investment to estimate planned plant and equipment spending for each quarter.

Comparing the spending for the coming year reported in the Bureau's fourth-quarter survey to the actual spending subsequently reported by these respondents shows that the survey can predict the rate of growth of this nominal capital spending fairly accurately (Table 1). During the 1980s and early 1990s, a period when the models failed to predict accurately the construction of nonresidential structures, this survey often predicted its measure of capital spending more accurately than most of the models predicted total nominal investment spending as reported in the national accounts. The survey misstated the annual growth of capital spending with an average absolute error of approximately 2.5 percentage points; the models misstated the annual growth of investment with average absolute errors exceeding 6 percentage points.

Although the Census survey often predicted its measure of capital spending comparatively accurately, the survey has not necessarily predicted aggregate investment spending nearly as well, because the relationship between the capital spending reported by the survey's respondents and the investment spending reported in the national accounts has been changing, especially since the 1970s. From 1960 to 1980, the actual capital spending reported by the respondents to the Census survey varied between 77 percent and 85 percent of the nonresidential investment reported in the national accounts. Between 1981 and 1991, this ratio increased almost steadily from 80 percent to 96 percent.

Results such as those shown in Table 1 do suggest that the Census survey, nonetheless, may be an important ingredient for forecasting accurately the investment spending of businesses. The demand for

Table 1
Forecast Errors for Projections of Nominal Investment Spending[a]

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Survey Data:												
Census Bureau	−2.3	−1.2	−8.8	−.6	−1.5	.5	−5.0	−1.0	1.5	2.2	−2.7	−3.4
Models:												
Accelerator	3.6	10.0	13.8	10.8	12.4	11.6	2.9	−1.9	−2.9	−6.3	−6.6	−9.4
Neoclassical	8.5	15.4	17.2	11.8	10.2	6.5	−2.5	−4.6	−4.7	−7.1	−4.3	−4.7
q Model	8.0	7.7	1.6	−2.2	6.6	9.4	−.1	−6.8	−6.2	−3.5	−8.1	−16.5
Cash Flow	8.5	13.4	13.9	6.6	9.2	10.3	9.2	2.2	−1.6	2.7	10.9	11.3
Autoregression												
with output	9.1	14.8	15.8	8.2	8.2	7.9	1.5	−.6	.8	−.1	2.4	1.9
without output	7.2	12.0	8.2	5.0	18.5	23.5	20.1	19.7	24.7	26.3	27.2	21.9

[a]The nominal Census Bureau annual survey data are compared to the reported nominal investment by the respondents to the survey. The model forecasts are the average of the quarterly model forecasts for equipment and nonresidential structures multiplied by their respective deflators found in Kopcke (1993). The errors shown are actual less predicted as a percentage of actual investment.
Source: Survey data provided by the U.S. Bureau of the Census.

investment goods, after all, depends on investors' expectations of the future. Although investors' views are grounded in their previous experiences, encouraging forecasters to consult previous sales, profits, and costs in order to predict future capital spending, these predictions might benefit considerably by incorporating the direct measures of investors' sentiments that are reported in the Census survey.

Even if surveys of businesses' plans for capital spending provided the most accurate forecasts of investment spending, statistical models would remain useful analytical tools. Statistical models may forecast investment spending over intervals of time not covered by surveys. Moreover, the models may describe the influence of economic conditions on investment spending, so that forecasts may adapt when these conditions change. Finally, some models permit policymakers to assess the potential consequences of changing monetary or fiscal policies. The collection of survey data rich enough to satisfy these objectives, even if feasible, is impractical.

II. The Contribution of Surveys to the Forecasts of Models of Investment Spending

Surveys and statistical models often complement one another. Few forecasts, for example, rest on the projections of models alone. Often the projections of statistical models are adjusted according to forecasters' assessments of business conditions. These adjustments may reflect the results of the Census surveys.

The potential value of surveys may not be the same for all statistical models of investment. If the sentiment recorded in a survey were correlated closely with previous changes in output, for example, then those models that use past output to forecast investment might benefit less from the survey than other models. Furthermore, because the models for purchases of nonresidential structures have performed relatively poorly since the mid 1970s, these models might gain more from surveys than models for purchases of producers' durable equipment.

This section examines the potential contribution of surveys to the five statistical models of investment (Table 2) presented in a previous article, "The Determinants of Business Investment" (Kopcke 1993). For this article, the models were modified so that they consider only previous values of their explanatory variables—output, cash flow, and the cost of capital. Their forecasts of investment this quarter do not depend on the values of their explanatory variables this quarter.

Each model of investment spending was estimated three times (see the Appendix) using data from 1960 to the late 1970s. The first version includes only lagged values of output, cash flow, or the cost of capital as explanatory variables for the accelerator, neoclassical, q, or cash flow models. For the autoregression, lagged values of investment were included, and then both lagged investment and lagged output. The second version is identical to the first except that each model also includes the anticipated capital spending as reported in the Census survey. The third

Table 2
The Models of Investment

Accelerator

$$I_t = a + \sum_{i=0}^{n} b_i Q_{t-i} + cK_{t-1}$$

Neoclassical

$$I_t = a + \sum_{i=0}^{n} b_i \frac{Q_{t-i}}{UCC_{t-i-1}} + \sum_{i=0}^{n} c_i \frac{Q_{t-i}}{UCC_{t-i}} + dK_{t-1}$$

q

$$I_t = a + \sum_{i=0}^{n} b_i[(q-1)_{t-i}K_{t-1-i}] + cK_{t-1}$$

Cash Flow

$$I_t = a + \sum_{i=0}^{n} b_i \left(\frac{F}{C}\right)_{t-i}$$

Autoregression

$$I_t = a + \sum_{i=1}^{n} b_i I_{t-i}$$

Explanation of Symbols

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

version resembles the second except that the previous period's investment spending replaces the spending reported in the Census survey.

These three versions of each model are used to forecast investment spending from the late 1970s to the present. Comparing the models' projections of investment spending helps isolate the potential contribution of the Census survey data to forecasts of investment. The forecasts from the second version of each model should be more accurate than those from the first version if the survey includes information that is not already represented in the models' other explanatory variables. This comparison, however, may overstate the contribution of the survey for at least two reasons.

First, the omission of contemporaneous output, cash flow, and capital costs may penalize the first version of each model too greatly. Although the actual values of these variables may not be known at the time of the forecast, reasonably accurate projections may be available. This potential penalty does not appear to be substantial for the quarterly forecasts during the 1980s and early 1990s, but it may be more important for the annual forecasts.[1]

Second, the survey data may reduce forecast errors simply because they prevent the models from wandering off course. The surveys reflect the recent amount of capital spending—this period's anticipated spending very much resembles last period's outlays. No model, other than the autoregression, includes investment spending among its explanatory variables; consequently, when these models stray off course, the survey, as a surrogate for recent investment spending, allows them to make midcourse corrections. In this case, the survey makes no unique contribution, because this midcourse correction might be accomplished in other ways—for example, by including the investment spending from the previous quarter instead of the survey among the explanatory variables. If the survey data contain unique, timely information, then the second version of each model should tend to be more accurate than the third version (which replaces the survey data with lagged investment). If the surveys essentially are surrogates for the recent amount of investment spending, then the third version of each model may be most accurate.

III. Quarterly Forecasts

The single most important ingredient for accurate one-quarter forecasts of investment spending during the 1980s and early 1990s was the value of investment spending during the preceding quarters. The value of adding surveys of planned capital spending to models that already included output, cash flow, or the cost of capital was not as great as the value of adding the previous quarter's investment spending. Furthermore, once prior investment had been taken into account, other variables—output, cash flows, and the cost of capital from previous quarters—tended to contribute comparatively little to the accuracy of forecasts.

[1] The quarterly forecasts presented in Kopcke (1993) take full advantage of the contemporaneous values of these explanatory variables. The quarterly forecasts described below do not. Yet the errors of these two sets of forecasts are very similar, according to the statistics reported in Table 7 of the previous article and in the uppermost panels of Tables 4 and 5 of this article.

Table 3
Selected Statistics of the Models for Quarterly Investment in Equipment, for the Estimation Period 1962:I to 1979:IV

Model	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion	Autocorrelation Coefficient	Number of Lags
			Without Survey Data			
Accelerator	5.8	7.2	27.8	6.9	.61	3
Neoclassical	4.1	5.0	12.9	.0	.42	13
q Model	11.8	14.0	62.5	44.4	.86	5
Cash Flow	9.9	11.8	52.8	25.0	.70	5
Autoregression						
without output	3.5	4.7	11.1	1.4	n.a	4
with output	3.1	4.1	4.2	1.4	n.a.	4
			With Survey Data			
Accelerator	5.3	6.6	19.4	4.2	.47	3
Neoclassical	3.7	4.4	2.9	.0	.28	13
q Model	8.1	10.1	45.8	22.2	.59	5
Cash Flow	6.4	8.5	29.2	11.1	.39	5
Autoregression						
without output	3.5	4.7	12.5	2.8	n.a.	4
with output	3.1	4.1	4.2	.0	n.a.	4
			With Lagged Investment in Equipment			
Accelerator	3.2	4.4	5.6	1.4	.00	3
Neoclassical	3.2	3.9	4.3	.0	.01	13
q Model	3.3	4.8	11.1	1.4	.05	5
Cash Flow	3.6	5.0	11.1	5.6	.02	5

Tables 3 and 4 describe the models' errors for purchases of producers' durable equipment; Tables 5 and 6 describe the errors for purchases of nonresidential structures. The first table in each pair summarizes the models' errors during the period of estimation from the early 1960s to the late 1970s. The second table summarizes the models' forecast errors from the late 1970s to the present. Figure 1 shows the correspondence between the models' descriptions of spending on equipment and actual outlays; Figure 2 compares the descriptions of spending on structures with actual outlays.

For explaining purchases of equipment, the accelerator, neoclassical, and autoregression models generally benefited negligibly from the survey. During the estimation period, the mean absolute errors and root mean squared errors fell only slightly, at most, for these four models after introducing the survey variable (Table 3, uppermost and middle panels). By most measures, the accelerator model tended to forecast equipment spending more accurately when the survey was *not* included, while the performance of the neoclassical and autoregression models improved only slightly by including the survey. Nevertheless, the surveys might have been valuable at times. Since 1989, for example, the accelerator model's forecasts of purchases of equipment benefited from the survey (Figure 1).

The cash flow model and the q model, which do not include a measure of output, benefited considerably more from including the survey. During the estimation period, the mean absolute errors and root mean squared errors for the cash flow and q models were reduced by almost one-third after including survey information (Table 3). During the forecast period, the survey reduced these error statistics by approximately one-half for the cash flow model (Table 4). Since 1986, the surveys made the forecasts of the q model and the cash flow model for equipment considerably more accurate (Figure 1).

Table 4
Selected Statistics of the Models for Quarterly Forecasts of the Investment in Equipment, 1980:I to 1992:I

Model	Mean Error	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion
			Without Survey Data		
Accelerator	−8.9	13.8	16.6	67.3	49.0
Neoclassical	5.2	10.9	13.4	61.2	36.7
q Model	−22.2	23.2	27.3	85.7	69.4
Cash Flow	16.2	19.2	26.5	73.5	42.9
Autoregression					
without output	1.1	6.0	7.7	30.6	8.2
with output	−2.0	5.5	6.9	18.4	6.1
			With Survey Data		
Accelerator	.5	17.0	18.5	87.8	73.5
Neoclassical	−5.2	9.3	11.8	49.0	30.6
q Model	−15.3	20.2	24.4	73.5	67.3
Cash Flow	−5.6	9.8	12.0	55.1	24.5
Autoregression					
without output	.4	6.0	7.6	26.5	8.2
with output	−1.3	5.3	6.7	18.4	4.1
			With Lagged Investment in Equipment		
Accelerator	−2.8	5.7	7.6	24.5	10.2
Neoclassical	.5	5.7	7.3	32.7	6.1
q Model	−7.7	9.1	11.3	51.0	24.5
Cash Flow	.2	5.4	7.0	22.4	4.1

For structures, the surveys reduced the errors of all models, but even with the assistance of the surveys, the performance of all the models, except the autoregression, remained very poor. The errors of all the models, with or without the survey data, generally were small during the estimation period (Table 5 and Figure 2). During the forecast period, however, the errors of the models often were large, especially in the late 1970s and early 1980s (Table 6 and Figure 2). Although the inclusion of the surveys reduced these errors substantially for all models except the neoclassical and autoregression, the errors remained very great. The surveys reduced the models' average forecast errors during the early 1980s, but by the early 1990s the surveys generally increased the models' errors in forecasting investment in structures.

For these one-quarter forecasts, the models benefited more from the inclusion of lagged investment spending than they did from the inclusion of the surveys. For both equipment and structures, the average forecast errors of all models including lagged investment spending were only a fraction of the average errors for the models that included the survey data (Tables 4 and 6). Furthermore, for both equipment and structures, the profile of these forecasts generally resembled that of investment spending (Figures 1 and 2).[2]

Previous investment not only contributed more to the accuracy of one-quarter forecasts than did the surveys, previous investment also contributed more than lagged cash flow or the cost of capital. The error statistics for the autoregression (Tables 4 and 6, uppermost panels) are generally at least as low as those for the versions of the other models that in-

[2] By including lagged *total* investment in the equations for equipment rather than the survey data, the average errors for most models generally were only marginally lower than those in the second panel of Table 4; however, the average errors for the cash flow equation were approximately one-fifth greater. By including *total* investment rather than the survey data in the equations for structures, the average errors were substantially less than those in the second panel of Table 5, but not as low as those in the lowest panel.

Figure 1

Actual Expenditures and Models' One-Quarter Forecasts of Investment in Equipment

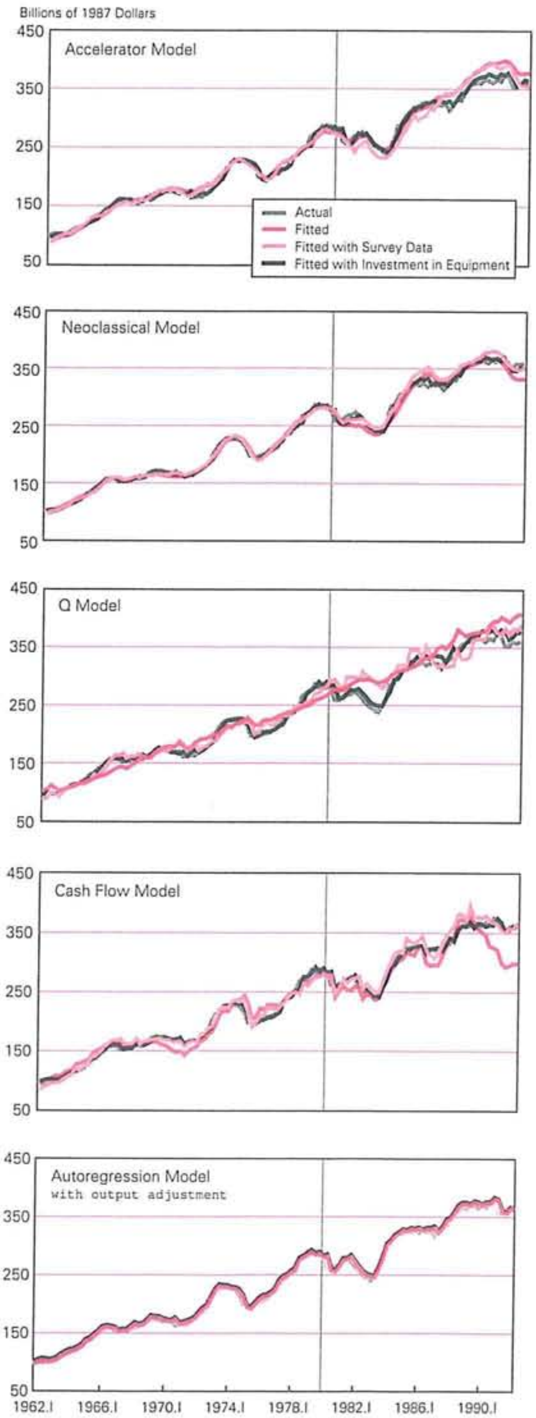

Figure 2

Actual Expenditures and Models' One-Quarter Forecasts of Investment in Structures

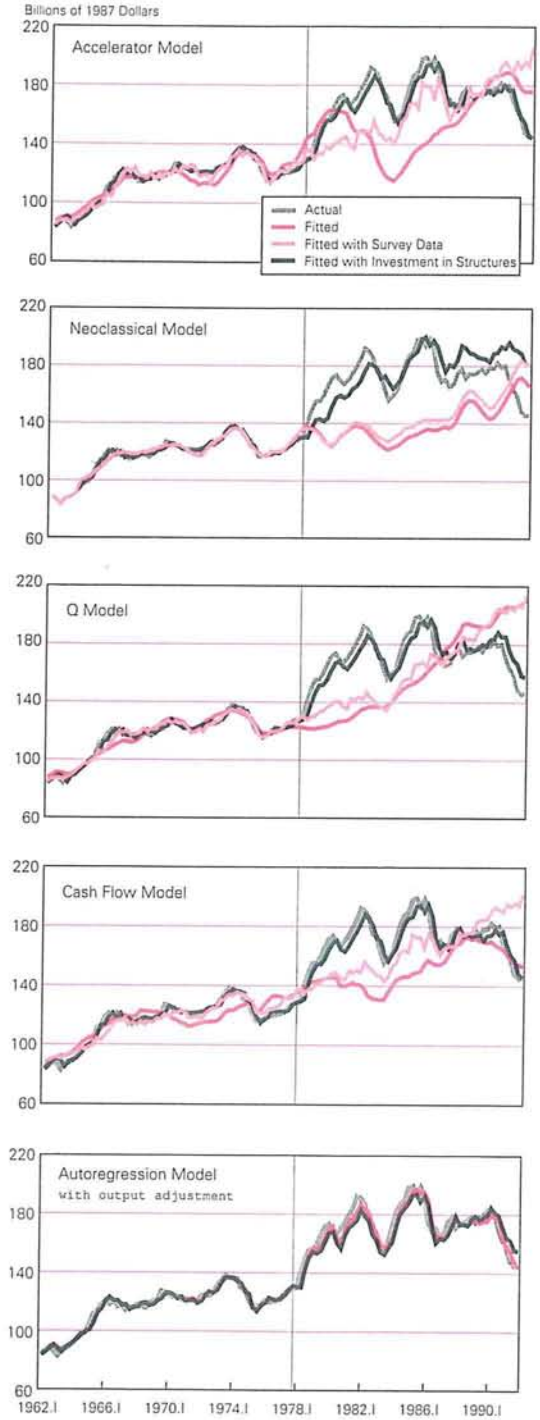

Table 5

Selected Statistics of the Models for Quarterly Investment in Nonresidential Structures, for the Estimation Period 1962:I to 1977:IV

Model	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion	Autocorrelation Coefficient	Number of Lags
			Without Survey Data			
Accelerator	4.8	5.6	10.9	1.6	.81	11
Neoclassical	2.2	2.7	.0	.0	.41	20
q Model	3.3	4.1	4.7	.0	.73	8
Cash Flow	6.5	7.4	31.3	6.3	.89	12
Autoregression						
without output	1.9	2.4	.0	.0	n.a.	4
with output	1.6	2.2	.0	.0	n.a.	4
			With Survey Data			
Accelerator	2.8	3.5	3.1	.0	.35	11
Neoclassical	2.2	2.7	.0	.0	.44	20
q Model	2.1	2.8	3.1	.0	.51	8
Cash Flow	3.9	4.7	7.8	.0	.76	12
Autoregression						
without output	1.9	2.3	.0	.0	n.a.	4
with output	1.6	2.1	.0	.0	n.a.	4
			With Lagged Investment in Structures			
Accelerator	1.7	2.2	.0	.0	.00	11
Neoclassical	1.4	1.7	.0	.0	.04	20
q Model	1.8	2.2	.0	.0	.01	8
Cash Flow	1.8	2.4	.0	.0	.02	12

Table 6

Selected Statistics of the Models for Quarterly Forecasts of the Investment in Nonresidential Structures, 1978:I to 1992:I

Model	Mean Error	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion
			Without Survey Data		
Accelerator	16.9	25.0	31.5	75.4	59.6
Neoclassical	32.1	35.1	38.5	94.7	89.5
q Model	11.7	31.3	35.1	96.5	86.0
Cash Flow	20.8	21.8	27.2	73.7	56.1
Autoregression					
without output	2.4	4.5	5.4	14.8	1.6
with output	2.0	4.5	5.4	16.4	1.6
			With Survey Data		
Accelerator	8.4	19.7	23.7	77.2	66.7
Neoclassical	26.8	31.9	35.0	94.7	87.7
q Model	8.6	25.7	29.9	84.2	78.9
Cash Flow	7.8	18.8	22.8	75.4	61.4
Autoregression					
without output	2.5	5.3	6.5	32.8	.0
with output	3.0	5.9	7.2	45.9	26.2
			With Lagged Investment in Structures		
Accelerator	2.6	4.7	5.7	19.3	1.8
Neoclassical	−3.6	12.5	15.3	66.7	36.8
q Model	.3	6.7	8.0	42.1	5.3
Cash Flow	2.2	4.7	5.7	15.8	.0

clude the previous quarter's investment spending (lowest panels). For predicting purchases of equipment, the version of the autoregression that includes lagged output was more accurate, but for predicting purchases of structures, adding output to the autoregression alters the error statistics negligibly.

IV. Annual Forecasts

Whereas transient influences may account for much of the quarterly change in investment spending, the role of more fundamental determinants of investment becomes more important over longer forecast horizons. For example, investment is not likely to diverge very much from its customary share of GDP for very long unless either the return on capital rises considerably or the cost of capital falls significantly. For the models that rely on output, cash flow, or the cost of capital to predict investment, the addition of lagged investment reduced the average errors of the one-year forecasts much less than it reduced those for the one-quarter forecasts. For purchases of equipment, the accuracy of the models generally improved negligibly, at best, after the inclusion of lagged investment.

Because these tests constrain all models to rely on lagged values of their explanatory variables, these results may overstate the contribution of surveys and lagged investment in these models. As the forecast horizon expands to a year or more, the course of investment in the future often deviates considerably from that implied by previous investment. Accordingly, informed judgments about prospective GDP, profits, and the cost of capital may become essential ingredients for longer-run forecasts.[3]

Tables 7 and 8 describe the models' errors for purchases of producers' durable equipment; Tables 9 and 10 describe the errors for purchases of nonresidential structures. The first table in each pair summarizes the models' errors during the period of estimation ending in the late 1970s. The second table summarizes the models' forecast errors from the late 1970s to the present. Figure 3 shows the correspondence between the models' descriptions of spending on equipment and actual outlays; Figure 4 compares the descriptions of spending on structures with actual outlays.

For equipment, the accelerator, neoclassical, and autoregression models benefited little from the inclusion of the surveys, while the q and cash flow models conformed to the course of investment more closely after taking the surveys into account (Figure 3). The cash flow model benefited the most from the survey (Tables 7 and 8, uppermost and middle panels). During the estimation period its mean absolute error and its root mean squared error fell by one-quarter after adding the survey. During the forecast period, these average errors fell by one-third.

For structures, all models except the autoregression benefited to a degree by taking the surveys into account. During the estimation period, the surveys reduced the error statistics most for the accelerator and cash flow models (Table 9). During the forecast period, the average errors of the q and cash flow models fell the most after the inclusion of the surveys (Table 10). The autoregression's average error in forecasting investment in structures increased substantially after the survey was added to its equations.

For the one-year forecasts, the versions of the models using the previous year's investment instead of the surveys often were more accurate than the versions that used the surveys. But, for these one-year forecasts, the models generally benefited less from this substitution than they did for the one-quarter forecasts. The average errors for equipment were nearly identical for the survey and the lagged investment versions of the models (Table 8, middle and lowest panels).

The role of fundamental determinants of investment becomes more important over longer forecast horizons.

Although the average errors for the forecasts of structures were lower when lagged investment replaced the surveys (Table 10), the forecasts that included the surveys often anticipated more accurately the turning points in the course of this investment (Figure 4). The significance of this observation is qualified, however. By the design of these tests, the forecasts that do not include the surveys use the average values of variables dated a year or more

[3] The extended forecasts presented in Kopcke (1993) show that the projections from the simple autoregression (without an adjustment for output) stray from the course of investment and that the profile of these projections does not resemble very closely that of actual investment.

Table 7

Selected Statistics of the Models for Annual Investment in Equipment, for the Estimation Period 1962 to 1979

Model	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion	Autocorrelation Coefficient	Number of Lags
			Without Survey Data			
Accelerator	8.4	10.0	44.4	22.2	.18	0
Neoclassical	3.5	4.2	6.3	.0	.02	4
q Model	11.8	14.5	66.7	50.0	.29	0
Cash Flow	11.8	15.7	50.0	38.9	.16	2
Autoregression						
without output	8.9	9.4	61.1	11.1	n.a.	3
with output	5.1	5.8	16.7	.0	n.a.	3
			With Survey Data			
Accelerator	8.1	9.9	44.4	22.2	.13	0
Neoclassical	3.5	4.2	6.3	.0	.02	4
q Model	8.1	10.2	38.9	27.8	.10	0
Cash Flow	9.5	11.5	50.0	27.8	.15	2
Autoregression						
without output	8.6	9.2	61.1	5.6	n.a.	3
with output	5.1	5.7	16.7	.0	n.a.	3
			With Lagged Investment in Equipment			
Accelerator	7.9	9.5	44.4	27.8	.27	0
Neoclassical	2.5	3.7	6.3	.0	.0	4
q Model	10.0	12.9	55.6	33.3	.17	0
Cash Flow	9.7	13.4	38.9	33.3	.03	2

Table 8

Selected Statistics of the Models for Annual Forecasts of the Investment in Equipment, 1980 to 1991

Model	Mean Error	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion
			Without Survey Data		
Accelerator	−10.1	15.7	19.3	58.3	50.0
Neoclassical	2.1	12.3	14.2	75.0	50.0
q Model	−26.2	26.2	30.5	83.3	75.0
Cash Flow	14.0	20.4	24.3	83.3	66.7
Autoregression					
without output	−6.8	15.7	20.3	75.0	41.7
with output	−7.4	14.6	16.1	83.3	58.3
			With Survey Data		
Accelerator	−6.1	16.2	19.2	66.7	58.3
Neoclassical	1.0	12.3	14.1	75.0	50.0
q Model	−12.9	22.3	26.3	91.7	66.7
Cash Flow	−8.5	13.6	16.1	75.0	58.3
Autoregression					
without output	−10.0	15.0	20.9	50.0	41.7
with output	−6.5	14.3	15.9	75.0	58.3
			With Lagged Investment in Equipment		
Accelerator	−10.1	16.3	20.2	66.7	50.0
Neoclassical	7.6	13.1	16.0	75.0	25.0
q Model	−19.1	21.3	24.4	91.7	83.3
Cash Flow	.5	12.7	15.4	75.0	25.0

Figure 3

Actual Expenditures and Models' One-Year Forecasts of Investment of Equipment

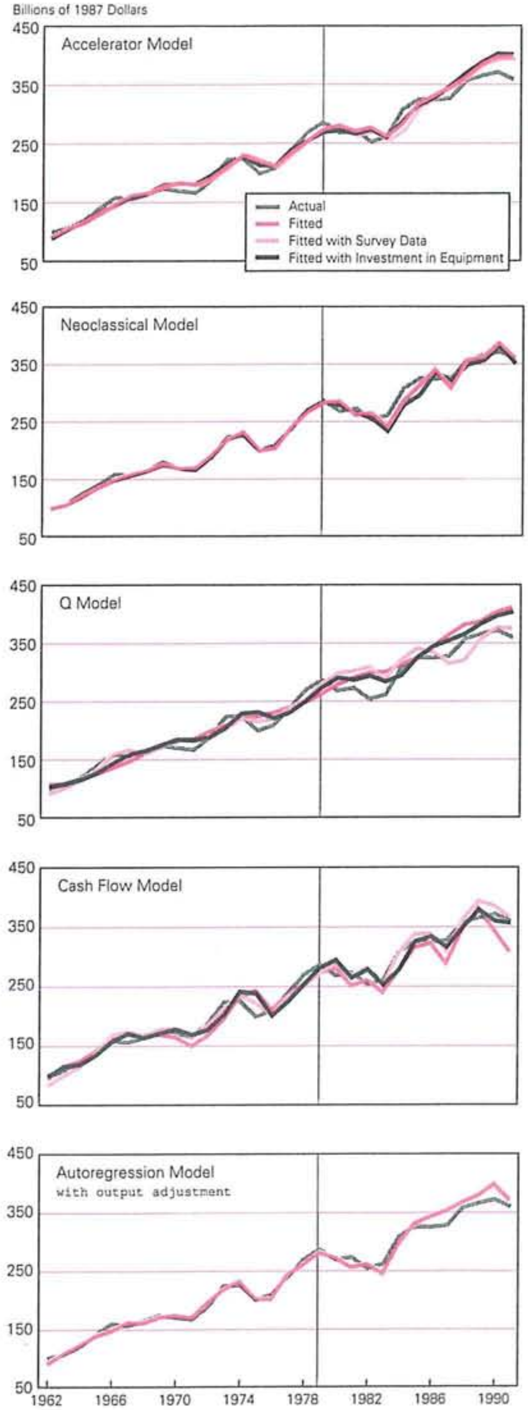

Figure 4

Actual Expenditures and Models' One-Year Forecasts of Investment in Structures

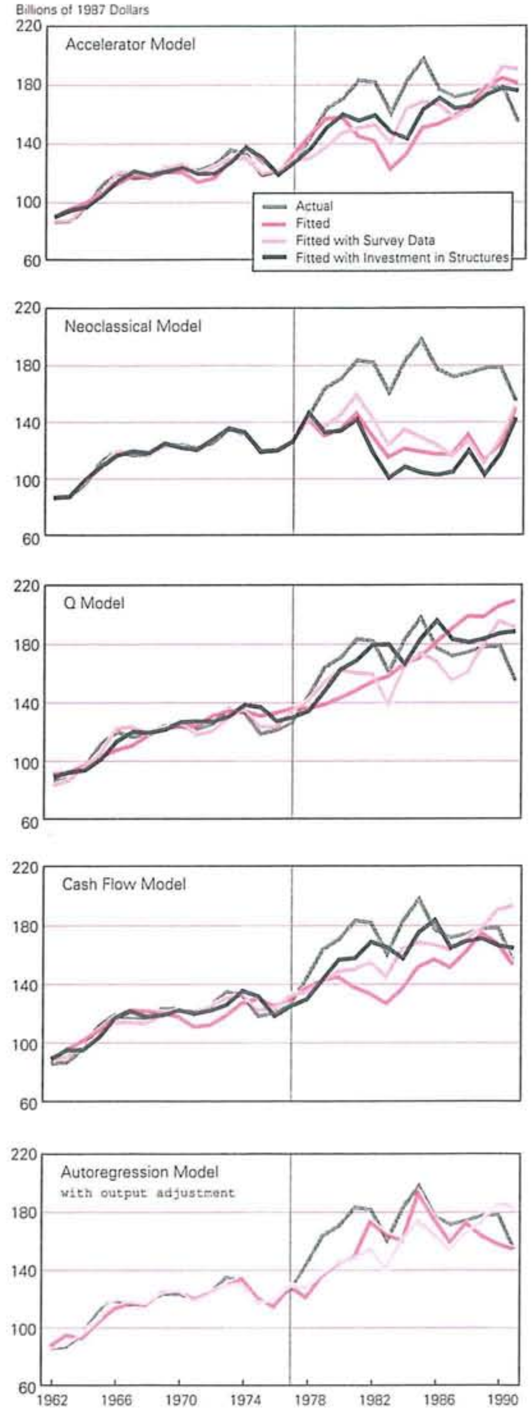

Table 9

Selected Statistics of the Models for Annual Investment in Nonresidential Structures, for the Estimation Period 1962 to 1977

Model	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion	Autocorrelation Coefficient	Number of Lags
			Without Survey Data			
Accelerator	5.2	5.9	18.8	.0	.16	0
Neoclassical	1.5	1.9	.0	.0	.08	4
q Model	5.4	6.9	31.3	6.3	.50	0
Cash Flow	6.6	7.7	31.3	6.3	.34	2
Autoregression						
without output	3.7	4.4	6.3	.0	n.a.	3
with output	3.2	4.0	6.3	.0	n.a.	3
			With Survey Data			
Accelerator	2.1	2.6	.0	.0	.01	0
Neoclassical	1.2	1.7	.0	.0	.12	4
q Model	3.5	4.3	6.3	.0	.07	0
Cash Flow	3.3	3.9	.0	.0	.27	2
Autoregression						
without output	3.0	3.6	.0	.0	n.a.	3
with output	1.9	2.5	.0	.0	n.a.	3
			With Lagged Investment in Structures			
Accelerator	4.2	5.2	12.5	.0	.04	0
Neoclassical	1.5	1.9	.0	.0	.05	4
q Model	5.1	6.5	12.5	6.3	.15	0
Cash Flow	4.2	5.5	18.8	6.3	.01	2

Table 10

Selected Statistics of the Models for Annual Forecasts of the Investment in Nonresidential Structures, 1978 to 1991

Model	Mean Error	Mean Absolute Error	Root Mean Squared Error	Percent of Absolute Errors Exceeding $8 Billion	Percent of Absolute Errors Exceeding $13 Billion
			Without Survey Data		
Accelerator	16.9	22.2	27.8	64.3	50.0
Neoclassical	44.3	44.3	48.9	85.7	85.7
q Model	.9	22.9	26.3	78.6	78.6
Cash Flow	23.5	23.5	28.6	78.6	64.3
Autoregression					
without output	10.9	13.2	16.4	71.4	42.9
with output	13.0	13.8	17.4	57.1	50.0
			With Survey Data		
Accelerator	12.5	19.8	22.0	92.9	78.6
Neoclassical	38.6	38.6	43.5	85.7	85.7
q Model	7.7	15.9	18.4	78.6	64.3
Cash Flow	9.8	17.5	20.6	78.6	57.1
Autoregression					
without output	9.5	18.0	20.8	71.4	71.4
with output	13.5	19.1	21.0	85.7	71.4
			With Lagged Investment in Structures		
Accelerator	12.6	15.6	19.3	71.4	35.7
Neoclassical	53.2	53.4	59.0	92.9	85.7
q Model	−1.4	13.4	15.3	78.6	50.0
Cash Flow	10.3	13.4	15.2	64.3	42.9

before the date of the forecast. Therefore, these forecasts cannot benefit from the more current information that often is necessary for timing turning points accurately. The forecasts that include the annual survey by the Census Bureau, however, incorporate more timely information, because these surveys are taken just before the beginning of the year. Accordingly, these forecasts should tend to anticipate turning points more accurately.

The one-year results suggest that accurate longer-term forecasts might depend on variables other than previous investment spending and output. For the one-quarter forecasts, the average errors for the autoregression were only a fraction of those for the other models, but for the one-year forecasts of purchases of equipment, the average errors of the autoregressions were more nearly comparable to those of the other models (Table 8, uppermost panel).[4] Adding either the surveys or the previous year's purchases of equipment to these models altered the average forecast errors only negligibly for the accelerator and neoclassical models, while the average errors for the q and cash flow models were reduced by one-fifth and one-third, respectively. The autoregression predicted annual purchases of structures more accurately than other models (Table 10, uppermost panel); however, compared to the results for the one-quarter forecasts, the autoregression has lost much of its relative advantage.

V. Conclusions

Surveys of plans for capital spending, in principle, are a promising ingredient for forecasts of investment. Statistical models of investment, as helpful as they are for both projecting and analyzing the flow of investment, nevertheless produce uncomfortably large errors, in the opinion of many policymakers. If we were confident that purchases of producers' durable equipment in 1993 will be 15 percent greater than they were in 1992, the need for an investment tax credit might not seem so compelling. The prospect of a 5 percent increase in equipment spending, however, might foster considerable interest in tax incentives for investors. Inasmuch as the magnitudes of average annual forecast errors for statistical models are so substantial for purchases of equipment and for purchases of nonresidential structures, these models too frequently cannot reassure policymakers that prospective investment spending will meet their goals.

Despite the promise of the Census Bureau's survey of capital spending, its ability to predict investment, as reported in the national accounts, is disappointing. The survey does not cover all types of business or all industries, and the capital spending reported by participating businesses does not necessarily match the concept of investment that is reported in the national accounts. Though this survey often anticipates fairly accurately the actual capital spending reported by its respondents, the information in the survey does not improve the performance of statistical models of aggregate business investment spending, because the relationship between respondents' capital spending and aggregate investment can change considerably from year to year. Since the 1970s, for example, the capital spending covered by the survey has increased significantly relative to aggregate investment.

When conditions are especially unsettled, forecasters require statistical models to form a consistent forecast.

For forecasts as short as one quarter, the information in the Census survey has not been as valuable as that inherent in the data for investment spending during previous quarters. Quarter-to-quarter changes in investment seem to be dominated by transient influences that are difficult to describe. The statistical models themselves find that knowledge of cash flow, the cost of capital, and perhaps even output during previous quarters may contribute comparatively little to the forecast once previous investment is taken into account.

For forecasts extending over horizons as long as a year or more, the information in the Census survey has not been as valuable as that inherent in a variety of economic data. Over longer horizons, fundamental trends tend to dominate the course of investment

[4] In Kopcke (1993), in forecasts extending over horizons longer than one year, autoregressions were not as accurate as other descriptions of investment that included output, cash flow, or the cost of capital. These other descriptions benefited, of course, from the information contained in the actual values of these other variables. But the results suggest that with reasonably accurate forecasts of output, cash flow, and the cost of capital these models would still possess an edge over autoregressions.

spending. To a degree, knowing the past course of investment, the "inertia" in capital spending, helps predict future investment. But in this case, the role of output, cash flow, and the cost of capital in determining capital spending also becomes more important. The responses recorded in the Census survey reflect less accurately the amount of investment that will be reported in the national accounts one year in advance than they reflect this spending one quarter in advance.

Perhaps, in the future, the relationship between the capital spending covered by the Census survey and the aggregate investment spending of businesses might become more stable, making the survey a more reliable indicator of aggregate investment spending. Even so, policymakers would continue to rely on statistical models for much of their analysis. A more extensive survey might confidently forewarn policymakers that investment will not meet their standards, but it cannot describe the motives of investors, suggesting how different government policies may alter these motives. Furthermore, surveys are fallible. The forecasts of investment revealed in surveys are no better than the respondents' various readings of economic conditions at the time the survey is taken. When conditions are especially unsettled and the readings of respondents are especially discordant, forecasters require statistical models to form a consistent forecast, anticipating how some businesses may revise their outlook for business conditions and alter their plans for capital spending.

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Appendix

Sources of Data: All data are from the U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts (NIPA) unless otherwise noted. Measures of stocks of assets and flows of goods or services are expressed in 1987 dollars.

IS, IE: Investment in nonresidential structures, and investment in producers' durable equipment, respectively, for all private businesses. The quarterly investment data are expressed at an annual rate.

KS, KE: Capital stock of structures, and equipment, respectively. Quarterly estimates of the stock of capital were derived from year-end stocks by a nonlinear interpolation assuming the perpetual inventory method and assuming a constant quarterly rate of depreciation throughout the year that is consistent with published data for the end of each year.

EXPITOTL, YRAHEAD: Total expected investment for the next quarter and the next year, respectively. Anticipated total investment is taken from U.S. Bureau of the Census, *Plant and Equipment Expenditure and Plans*. Anticipated investment is converted to constant dollars using the implicit price deflator for fixed nonresidential investment.

RGDPBUS: Real gross domestic product for businesses; quarterly data expressed at an annual rate.

F: Cash flow for businesses, using data from the Board of Governors of the Federal Reserve System, Flow of Funds Section, for the nonfinancial corporate business sector. Cash flow is defined as profits less taxes and dividends, with capital consumption adjustment and depreciation allowances plus capital consumption allowances.

CS, CE, CT: Implicit price deflators for nonresidential structures, producers' durable equipment, and total investment.

NYSEBOND: Market value as a percent of par value for all New York Stock Exchange listed bonds. Annual data come from the NYSE *Fact Book* for various years. Quarterly data were derived using a nonlinear interpolation based on the pattern of new Aa utility bond yields.

q: The ratio of the market value of nonfinancial corporations to the replacement value of their net assets. Market value equals equity less farm net worth plus net interest-bearing debt, which is the sum of bank loans, commercial paper, acceptances, finance company loans, U.S. government loans, and adjusted bonds (AB).

$$AB = .5 * MTG + NYSEBOND * (.5 * MTG + TEB + CB)$$

MTG = commercial mortgages

TEB = tax exempt bonds

CB = corporate bonds

The replacement value of net nonfinancial corporate assets equals total assets less profit taxes payable, trade debt, and foreign direct investment in the United States. Except for NYSEBOND, all data come from the Board of Governors of the Federal Reserve System, Flow of Funds.

INFLATN: Rate of inflation expected over the coming five years. For 1980:IV–1992:I, INFLATN is the average of monthly surveys done 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 of the CPI for 1980:IV–1992:I; this equation was used to obtain expectations for the period 1959:I–1980:III.

RE, RS: User cost of capital for equipment, and nonresidential structures.

$$RE = (CE/CT)(.15 + D)(1 - ITC - TAX * WE - .3 * (1 - DEBTE))/(1 - TAX)$$

$$RS = (CS/CT)(.05 + D)(1 - TAX * WS - .3 * (1 - DEBTS))/(1 - TAX)$$

The rate of depreciation is 0.15 for equipment and 0.05 for structures.

D, the discount rate for corporate profits after corporate income taxes, 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. This definition of D is inspired by the Gordon growth model for valuing equities.

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 is the present value of depreciation allowances for equipment using the most "accelerated" formula permitted by law. From 1959: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:I, equipment was depreciated using the Modified Accelerated Cost Recovery System. Tax life for equipment is the weighted average of the tax lives 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 is similarly defined for structures. Structures were depreciated according to Sum of the Year's Digits from 1959:I through 1969:II; from 1969:III through 1981:II, structures were depreciated according to the 150 percent Declining Balance Method; from 1981:III through 1986:IV, buildings were depreciated according to the Accelerated Cost Recovery System, and the Modified Accelerated Cost Recovery System was used thereafter. The discount rate used equals INFLATN times (1 + 0.015).

DEBTE and DEBTS are the present value of debt service charges after taxes per dollar borrowed, for equipment and for structures. The interest rate on debt equals the prevailing Aa new utility rate. The maturity of the loan equals the tax life of the capital good. The discount rate is the same as that for WE and WS. DEBT equals unity when the Aa utility rate, after taxes, equals the discount rate; DEBT exceeds unity when the after-tax interest rate exceeds the discount rate.

Annual data are averages of the quarterly data for each year.

Unless otherwise noted, all quarterly regressions for equipment were run from 1962:I to 1979:IV, while those for structures were run from 1962:I to 1977:IV. Similarly, annual regressions for equipment were run from 1962 to 1979, while those for structures were run from 1962 to 1977, unless noted otherwise. Lag coefficients in all models other than the autoregression were constrained to a third-degree polynomial when the lags were sufficiently long. The last lag coefficients for the quarterly cash flow structures equation were constrained to equal zero. Otherwise, the lag coefficients were not constrained.

The regressions were estimated by ordinary least squares with no allowance for autocorrelation of the errors. Inasmuch as the estimated first-order autocorrelation coefficients for the residuals from these equations could be as large as 0.9, the estimates of the variance of the errors (the root mean squared errors) are biased toward zero (Kiviet and Krämer 1992). When a first-order autocorrelation coefficient for the errors is estimated with the other coefficients, the procedure essentially constructs the errors and their harmonics to obtain the best fit. Because the harmonic of the constructed error is likely to resemble those of the other variables, the estimates of the coefficients for the explanatory variables may be biased (Yule 1926). This bias appeared to be especially great in the equations for structures. For further discussion of these equations see Kopcke (1993).

Quarterly Models of Investment in Equipment and Structures

Accelerator

$$IS = 23.45 + \sum_{i=1}^{11} b_i RGDPBUS_{t-i} - .20KS_{t-1}$$

b_1 = .0557
b_2 = .0318
b_3 = .0171
b_4 = .0094
b_5 = .0071
b_6 = .0080
b_7 = .0102
b_8 = .0119
b_9 = .0110
b_{10} = .0057
b_{11} = −.0060
Sum = .1618

$$IS = 67.99 + \sum_{i=1}^{11} b_i RGDPBUS_{t-1} + .03KS_{t-1} + .51EXPITOTL$$

b_1 = .0101
b_2 = −.0060
b_3 = −.0137
b_4 = −.0150
b_5 = −.0119
b_6 = −.0064
b_7 = −.0006
b_8 = .0036
b_9 = .0041
b_{10} = −.0012
b_{11} = −.0142
Sum = −.0512

$$IS = 4.76 + \sum_{i=1}^{11} b_i RGDPBUS_{t-i} - .01KS_{t-i} + .92IS_{t-1}$$

b_1 = .0196
b_2 = .0058
b_3 = −.0025
b_4 = −.0063
b_5 = −.0067
b_6 = −.0049
b_7 = −.0020
b_8 = .0009
b_9 = .0027
b_{10} = .0021
b_{11} = −.0019
Sum = .0070

$$IE = -162.16 + \sum_{i=1}^{3} b_i RGDPBUS_{t-i} - .11KE_{t-1}$$

b_1 = .1042
b_2 = .0628
b_3 = .0213
Sum = .1884

$$IE = -217.11 + \sum_{i=1}^{3} b_i RGDPBUS_{t-i} - .18KE_{t-1} - .34EXPITOTL$$

b_1 = .1036
b_2 = .0933
b_3 = .0831
Sum = .2799

$$IE = -41.92 + \sum_{i=1}^{3} b_i RGDPBUS_{t-i} - .03KE_{t-1} + .77IE_{t-1}$$

b_1 = .0708
b_2 = .0161
b_3 = −.0387
Sum = .0482

Neoclassical (period of fit for equipment: 1962:III–1979:IV, period of fit for structures: 1964:II–1977:IV)

$$IS = 39.84 + \sum_{i=1}^{20} b_i (RGDPBUS/RS)_{t-i} + \sum_{i=1}^{20} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) + .02KS_{t-1}$$

b_1 = .0004
b_2 = .0001
b_3 = −.0006
b_4 = −.0018
b_5 = −.0031
b_6 = −.0047
b_7 = −.0064
b_8 = −.0081
b_9 = −.0098
b_{10} = −.0114
b_{11} = −.0128
b_{12} = −.0139
b_{13} = −.0146
b_{14} = −.0149
b_{15} = −.0147
b_{16} = −.0139
b_{17} = −.0125
b_{18} = −.0103
b_{19} = −.0072
b_{20} = −.0033
Sum = −.1635

$c_1 = .0000$
$c_2 = .0009$
$c_3 = .0021$
$c_4 = .0034$
$c_5 = .0048$
$c_6 = .0064$
$c_7 = .0079$
$c_8 = .0094$
$c_9 = .0108$
$c_{10} = .0120$
$c_{11} = .0129$
$c_{12} = .0136$
$c_{13} = .0140$
$c_{14} = .0140$
$c_{15} = .0135$
$c_{16} = .0125$
$c_{17} = .0109$
$c_{18} = .0086$
$c_{19} = .0057$
$c_{20} = .0021$
Sum = .1653

$$IS = 43.86 + \sum_{i=1}^{20} b_i (RGDPBUS/RS)_{t-i}$$

$$+ \sum_{i=1}^{20} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) + .01KS_{t-1} + .07EXPITOTL$$

$b_1 = .0008$
$b_2 = .0018$
$b_3 = .0020$
$b_4 = .0018$
$b_5 = .0010$
$b_6 = -.0001$
$b_7 = -.0016$
$b_8 = -.0032$
$b_9 = -.0049$
$b_{10} = -.0066$
$b_{11} = -.0082$
$b_{12} = -.0097$
$b_{13} = -.0108$
$b_{14} = -.0116$
$b_{15} = -.0119$
$b_{16} = -.0116$
$b_{17} = -.0107$
$b_{18} = -.0090$
$b_{19} = -.0064$
$b_{20} = -.0029$
Sum = −.1018

$c_1 = -.0016$
$c_2 = -.0017$
$c_3 = -.0013$
$c_4 = -.0006$
$c_5 = .0004$
$c_6 = .0017$
$c_7 = .0031$
$c_8 = .0046$
$c_9 = .0061$
$c_{10} = .0075$
$c_{11} = .0088$
$c_{12} = .0098$
$c_{13} = .0106$
$c_{14} = .0111$
$c_{15} = .0110$
$c_{16} = .0105$
$c_{17} = .0094$
$c_{18} = .0076$
$c_{19} = .0051$
$c_{20} = .0018$
Sum = .1038

$$IS = -2.21 + \sum_{i=1}^{20} b_i (RGDPBUS/RS)_{t-i}$$

$$+ \sum_{i=1}^{20} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) - .00KS_{t-1} + .82IS_{t-1}$$

$b_1 = .0016$
$b_2 = .0041$
$b_3 = .0060$
$b_4 = .0073$
$b_5 = .0081$
$b_6 = .0085$
$b_7 = .0085$
$b_8 = .0082$
$b_9 = .0076$
$b_{10} = .0069$
$b_{11} = .0060$
$b_{12} = .0050$
$b_{13} = .0041$
$b_{14} = .0031$
$b_{15} = .0024$
$b_{16} = .0017$
$b_{17} = .0014$
$b_{18} = .0013$
$b_{19} = .0015$
$b_{20} = .0022$
Sum = .0954

$c_1 = -.0037$
$c_2 = -.0055$
$c_3 = -.0068$
$c_4 = -.0076$
$c_5 = -.0081$
$c_6 = -.0082$
$c_7 = -.0080$
$c_8 = -.0076$
$c_9 = -.0070$
$c_{10} = -.0062$
$c_{11} = -.0054$
$c_{12} = -.0045$
$c_{13} = -.0036$
$c_{14} = -.0027$
$c_{15} = -.0020$
$c_{16} = -.0014$
$c_{17} = -.0010$
$c_{18} = -.0009$

$c_{19} = -.0011$
$c_{20} = -.0016$
Sum $= -.0928$

$$IE = -30.37 + \sum_{i=1}^{13} b_i (RGDPBUS/RE)_{t-i} + \sum_{i=1}^{13} c_i (RGDPBUS_{t-i}/RE_{t-1-i}) + .10KE_{t-1}$$

$b_1 = .0027$
$b_2 = -.0134$
$b_3 = -.0259$
$b_4 = -.0350$
$b_5 = -.0411$
$b_6 = -.0444$
$b_7 = -.0451$
$b_8 = -.0435$
$b_9 = -.0399$
$b_{10} = -.0345$
$b_{11} = -.0275$
$b_{12} = -.0193$
$b_{13} = -.0100$
Sum $= -.3767$

$c_1 = .0157$
$c_2 = .0264$
$c_3 = .0345$
$c_4 = .0401$
$c_5 = .0433$
$c_6 = .0443$
$c_7 = .0432$
$c_8 = .0402$
$c_9 = .0353$
$c_{10} = .0288$
$c_{11} = .0208$
$c_{12} = .0113$
$c_{13} = .0006$
Sum $= .3844$

$$IE = -34.00 + \sum_{i=1}^{13} b_i (RGDPBUS/RE)_{t-i} + \sum_{i=1}^{13} c_i (RGDPBUS_{t-i}/RE_{t-1-i}) + .10KE_{t-1} + .18EXPITOTL$$

$b_1 = .0026$
$b_2 = -.0124$
$b_3 = -.0236$
$b_4 = -.0314$
$b_5 = -.0363$
$b_6 = -.0384$
$b_7 = -.0382$
$b_8 = -.0360$
$b_9 = -.0320$
$b_{10} = -.0267$
$b_{11} = -.0204$
$b_{12} = -.0133$
$b_{13} = -.0059$
Sum $= -.3120$

$c_1 = .0139$
$c_2 = .0236$
$c_3 = .0306$
$c_4 = .0351$
$c_5 = .0373$
$c_6 = .0374$
$c_7 = .0357$
$c_8 = .0323$
$c_9 = .0276$
$c_{10} = .0216$
$c_{11} = .0147$
$c_{12} = .0069$
$c_{13} = -.0013$
Sum $= .3154$

$$IE = -10.90 + \sum_{i=1}^{13} b_i (RGDPBUS/RE)_{t-i} + \sum_{i=1}^{13} c_i (RGDPBUS_{t-i}/RE_{t-1-i}) + .04KE_{t-1} + .66IE_{t-1}$$

$b_1 = .0036$
$b_2 = -.0057$
$b_3 = -.0123$
$b_4 = -.0163$
$b_5 = -.0182$
$b_6 = -.0184$
$b_7 = -.0171$
$b_8 = -.0148$
$b_9 = -.0118$
$b_{10} = -.0084$
$b_{11} = -.0050$
$b_{12} = -.0020$
$b_{13} = -.0003$
Sum $= -.1261$

$c_1 = .0060$
$c_2 = .0118$
$c_3 = .0157$
$c_4 = .0176$
$c_5 = .0178$
$c_6 = .0168$
$c_7 = .0147$
$c_8 = .0120$
$c_9 = .0088$
$c_{10} = .0057$
$c_{11} = .0028$
$c_{12} = .0005$
$c_{13} = -.0009$
Sum $= .1288$

q Model

$$IS = 1.70 + \sum_{i=1}^{8} b_i(q-1)_{t-1}KS_{t-1-i} + .09KS_{t-1}$$

b_1 = −.0022
b_2 = .0080
b_3 = .0120
b_4 = .0116
b_5 = .0086
b_6 = .0050
b_7 = .0025
b_8 = .0030
Sum = .0484

$$IS = 32.74 + \sum_{i=1}^{8} b_i(q-1)_{t-i}KS_{t-1-i} + .02KS_{t-1} + .28EXPITOTL$$

b_1 = .0025
b_2 = .0063
b_3 = .0065
b_4 = .0046
b_5 = .0018
b_6 = −.0004
b_7 = −.0006
b_8 = .0026
Sum = .0232

$$IS = 1.04 + \sum_{i=1}^{8} b_i(q-1)_{t-i}KS_{t-1-i} + .01KS_{t-1} + .88IS_{t-1}$$

b_1 = .0026
b_2 = .0049
b_3 = .0044
b_4 = .0021
b_5 = −.0008
b_6 = −.0030
b_7 = −.0033
b_8 = −.0007
Sum = .0062

$$IE = -30.57 + \sum_{i=1}^{5} b_i(q-1)_{t-i}KE_{t-1-i} + .21KE_{t-1}$$

b_1 = −.0346
b_2 = .0324
b_3 = .0321
b_4 = .0085
b_5 = .0057
Sum = .0441

$$IE = -8.87 + \sum_{i=1}^{5} b_i(q-1)_{t-i}KE_{t-1-i} - .02KE_{t-1} + .78EXPITOTL$$

b_1 = −.0276
b_2 = .0141
b_3 = .0085
b_4 = −.0178
b_5 = −.0383
Sum = −.0610

$$IE = -3.19 + \sum_{i=1}^{5} b_i(q-1)_{t-i}KE_{t-1-i} + .01KE_{t-1} + 1.01IE_{t-1}$$

b_1 = .0159
b_2 = .0177
b_3 = .0024
b_4 = −.0146
b_5 = −.0180
Sum = .0035

Cash Flow

$$IS = 25.32 + \sum_{i=1}^{12} b_i(F/CS)_{t-i}$$

b_1 = .1297
b_2 = .0721
b_3 = .0338
b_4 = .0117
b_5 = .0024
b_6 = .0027
b_7 = .0094
b_8 = .0191
b_9 = .0286
b_{10} = .0347
b_{11} = .0342
b_{12} = .0237
Sum = .4020

$$IS = 55.20 + \sum_{i=1}^{12} b_i(F/CS)_{t-i} + .32EXPITOTL$$

b_1 = −.0029
b_2 = −.0023
b_3 = −.0025
b_4 = −.0034
b_5 = −.0047
b_6 = −.0062
b_7 = −.0076
b_8 = −.0086
b_9 = −.0091
b_{10} = −.0087
b_{11} = −.0072
b_{12} = −.0044
Sum = −.0675

$$IS = 4.26 + \sum_{i=1}^{12} b_i(F/CS)_{t-i} + .93IS_{t-1}$$

b_1 = .0475
b_2 = .0173
b_3 = −.0026

$b_4 = -.0140$
$b_5 = -.0184$
$b_6 = -.0176$
$b_7 = -.0130$
$b_8 = -.0064$
$b_9 = .0006$
$b_{10} = .0064$
$b_{11} = .0093$
$b_{12} = .0077$
Sum = .0167

$$IE = -25.34 + \sum_{i=1}^{5} b_i (F/CE)_{t-i}$$

$b_1 = .6998$
$b_2 = .0661$
$b_3 = .0440$
$b_4 = .1776$
$b_5 = .0112$
Sum = .9987

$$IE = -42.84 + \sum_{i=1}^{5} b_i (F/CE)_{t-i} + .43EXPITOTL$$

$b_1 = .5892$
$b_2 = -.0356$
$b_3 = -.0016$
$b_4 = .1456$
$b_5 = -.1395$
Sum = .5580

$$IE = 1.03 + \sum_{i=1}^{5} b_i (F/CE)_{t-i} + .98IE_{t-1}$$

$b_1 = 0.1939$
$b_2 = -.0921$
$b_3 = -.0590$
$b_4 = .0370$
$b_5 = -.0600$
Sum = .0198

Autoregression

$$IS = 6.00 + \sum_{i=1}^{4} b_i IS_{t-i}$$

$b_1 = 1.1277$
$b_2 = .0587$
$b_3 = -.1832$
$b_4 = -.0516$
Sum = .9516

$$IS = 12.64 \sum_{i=1}^{4} b_i IS_{t-i} + .06EXPITOTL$$

$b_1 = 1.008$
$b_2 = .0518$
$b_3 = -.1405$
$b_4 = -.1425$
Sum = .7768

$$IS = 4.62 + \sum_{i=1}^{4} b_i IS_{t-i} + \sum_{i=1}^{3} c_i RGDPBUS_{t-i}$$

$b_1 = .8418$
$b_2 = .1980$
$b_3 = .0624$
$b_4 = -.1619$
Sum = .9403

$c_1 = .0323$
$c_2 = .0002$
$c_3 = -.0319$
Sum = .0006

$$IS = 16.21 + \sum_{i=1}^{4} b_i IS_{t-i} + \sum_{i=1}^{3} c_i RGDPBUS_{t-i} + .10EXPITOTL$$

$b_1 = .7871$
$b_2 = .1156$
$b_3 = .0398$
$b_4 = -.1739$
Sum = .7686

$c_1 = .0241$
$c_2 = .0005$
$c_3 = -.0306$
Sum = −.0060

$$IE = 2.68 + \sum_{i=1}^{4} b_i IE_{t-i}$$

$b_1 = 1.2674$
$b_2 = .0369$
$b_3 = -.3013$
$b_4 = -.0128$
Sum = .9902

$$IE = 1.28 + \sum_{i=1}^{4} b_i IE_{t-i} + .02EXPITOTL$$

$b_1 = 1.2519$
$b_2 = .0367$
$b_3 = -.3022$
$b_4 = -.0195$
Sum = .9669

$$IE = -28.50 + \sum_{i=1}^{4} b_i IS_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i}$$

$b_1 = .9052$
$b_2 = .1422$

$b_3 = -.1363$
$b_4 = -.1966$
Sum = .7145

$c_1 = .0369$
$c_2 = -.0040$
Sum = .0329

$$IE = -28.12 + \sum_{i=1}^{4} b_i IS_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i} - .03EXPITOTL$$

$b_1 = .9149$
$b_2 = .1407$
$b_3 = -.1292$
$b_4 = -.1958$
Sum = .7306

$c_1 = .0365$
$c_2 = -.0022$
Sum = .0343

Annual Models of Total Investment

Accelerator

$$IS = 30.68 + .11RGDPBUS_{t-1} - .13KS_{t-1}$$

$$IS = 71.30 - .04RGDPBUS_{t-1} + .01KS_{t-1} + .50YRAHEAD$$

$$IS = 24.16 + .06RGDPBUS_{t-1} - .08KS_{t-1} + 0.46IS_{t-1}$$

$$IE = -133.18 + .16RGDPBUS_{t-1} - .07KE_{t-1}$$

$$IE = -157.68 + .20RGDPBUS_{t-1} - .10KE_{t-1} - .15YRAHEAD$$

$$IE = -123.22 + .16RGDPBUS_{t-1} - .03KE_{t-1} - .34IE_{t-1}$$

Neoclassical (Period of fit for Structures: 1964–1977. Period of fit for Equipment: 1964–1979)

$$IS = 67.01 + \sum_{i=1}^{4} b_i (RGDPBUS/RS)_{t-i} + \sum_{i=1}^{4} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) + .02KS_{t-1}$$

$b_1 = -.0004$
$b_2 = -.0100$
$b_3 = -.0235$
$b_4 = -.0307$
Sum = −.0645

$c_1 = .0091$
$c_2 = .0160$
$c_3 = .0286$
$c_4 = .0100$
Sum = .0638

$$IS = 96.30 + \sum_{i=1}^{4} b_i (RGDPBUS/RS)_{t-i} + \sum_{i=1}^{4} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) - .01KS_{t-1} + .22YRAHEAD$$

$b_1 = -.0009$
$b_2 = -.0032$
$b_3 = -.0202$
$b_4 = -.0290$
Sum = −.0534

$c_1 = .0024$
$c_2 = .0124$
$c_3 = .0265$
$c_4 = .0090$
Sum = .0503

$$IS = 74.11 + \sum_{i=1}^{4} b_i (RGDPBUS/RS)_{t-i} + \sum_{i=1}^{4} c_i (RGDPBUS_{t-i}/RS_{t-1-i}) + .04KS_{t-1} - .22IS_{t-1}$$

$b_1 = -.0014$
$b_2 = -.0165$
$b_3 = -.0336$
$b_4 = -.0370$
Sum = −.0886

$c_1 = .0146$
$c_2 = .0253$
$c_3 = .0356$
$c_4 = .0118$
Sum = .0873

$$IE = -29.51 + \sum_{i=1}^{4} b_i (RGDPBUS/RE)_{t-i} + \sum_{i=1}^{4} c_i (RGDPBUS_{t-i}/RE_{t-1-i}) + .08KE_{t-1}$$

$b_1 = .0135$
$b_2 = -.0467$
$b_3 = -.0335$
$b_4 = -.0177$
Sum = −.0843

$c_1 = .0322$
$c_2 = .0389$
$c_3 = .0173$
$c_4 = .0079$
Sum $= .0963$

$$IE = -30.33 + \sum_{i=1}^{4} b_i(RGDPBUS/RE)_{t-i}$$

$$+ \sum_{i=1}^{4} c_i(RGDPBUS_{t-i}/RE_{t-1-i}) + .08KE_{t-1} + .02YRAHEAD$$

$b_1 = .0135$
$b_2 = -.0465$
$b_3 = -.0330$
$b_4 = -.0162$
Sum $= -.0822$

$c_1 = .0317$
$c_2 = .0388$
$c_3 = .0158$
$c_4 = .0075$
Sum $= .0938$

$$IE = -45.52 + \sum_{i=1}^{4} b_i(RGDPBUS/RE)_{t-i}$$

$$+ \sum_{i=1}^{4} c_i(RGDPBUS_{t-i}/RE_{t-1-i}) + .14KE_{t-1} - .68IE_{t-1}$$

$b_1 = .0113$
$b_2 = -.0536$
$b_3 = -.0517$
$b_4 = -.0451$
Sum $= -.1392$

$c_1 = .0481$
$c_2 = .0522$
$c_3 = .0441$
$c_4 = .0120$
Sum $= .1564$

q Model

$$IS = 6.99 + .02((q-1)*KS_{t-1})_{t-1} - .08KS_{t-1}$$

$$IS = 74.93 - .02((q-1)*KS_{t-1})_{t-1} - .07KS_{t-1} + .54YRAHEAD$$

$$IS = 8.43 + .00((q-1)*KS_{t-1})_{t-1} + .02KS_{t-1} + .70IS_{t-1}$$

$$IE = -33.06 + .05((q-1)*KE_{t-1})_{t-1} + .22KE_{t-1}$$

$$IE = -2.69 - .07((q-1)*KE_{t-1})_{t-1} - .02KE_{t-1} + .76YRAHEAD$$

$$IE = -16.71 + .03((q-1)*KE_{t-1})_{t-1} + .11KE_{t-1} + .52IE_{t-1}$$

Cash Flow

$$IS = 33.99 + \sum_{i=1}^{2} b_i(F/CS)_{t-i}$$

$b_1 = .2607$
$b_2 = .1050$
Sum $= .3656$

$$IS = 58.84 + \sum_{i=1}^{2} b_i(F/CS)_{t-i} + .33YRAHEAD$$

$b_1 = -.0291$
$b_2 = -.0657$
Sum $= -.0947$

$$IS = 20.87 + \sum_{i=1}^{2} b_i(F/CS)_{t-i} + .74IS_{t-1}$$

$b_1 = .1312$
$b_2 = -.0820$
Sum $= .0492$

$$IE = -14.23 + \sum_{i=1}^{2} b_i(F/CE)_{t-i}$$

$b_1 = 1.0725$
$b_2 = -.1036$
Sum $= .9689$

$$IE = -37.04 + \sum_{i=1}^{2} b_i(F/CE)_{t-i} + .52YRAHEAD$$

$b_1 = .6595$
$b_2 = -.2237$
Sum $= .4358$

$$IE = 3.50 + \sum_{i=1}^{2} b_i(F/CE)_{t-i} + .81IE_{t-1}$$

$b_1 = .4601$
$b_2 = -.2745$
Sum $= .1856$

Autoregression

$$IS = 25.95 + \sum_{i=1}^{3} b_iIS_{t-i}$$

$b_1 = 1.1330$
$b_2 = -.8712$

$b_3 = .5391$
Sum = .8009

$$IS = 52.44 + \sum_{i=1}^{3} b_i IS_{t-i} + .31YRAHEAD$$

$b_1 = .2204$
$b_2 = -.2408$
$b_3 = -.0667$
Sum = −.0871

$$IS = 24.92 + \sum_{i=1}^{3} b_i IS_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i}$$

$b_1 = .9920$
$b_2 = -.5068$
$b_3 = .6344$
Sum = 1.1196

$c_1 = .0279$
$c_2 = -.0441$
Sum = −.0162

$$IS = 65.70 + \sum_{i=1}^{3} b_i IS_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i} + .43YRAHEAD$$

$b_1 = .1851$
$b_2 = -.2139$
$b_3 = .2098$
Sum = .1810

$c_1 = -.0266$
$c_2 = -.0047$
Sum = −.0313

$$IE = 7.69 + \sum_{i=1}^{3} b_i IE_{t-i}$$

$b_1 = 1.4548$
$b_2 = -1.2027$
$b_3 = .7796$
Sum = 1.0317

$$IE = -1.85 + \sum_{i=1}^{3} b_i IE_{t-i} + .15YRAHEAD$$

$b_1 = 1.2625$
$b_2 = -1.0930$
$b_3 = .6951$
Sum = .8646

$$IE = -173.04 \sum_{i=1}^{3} b_i IE_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i}$$

$b_1 = -.9458$
$b_2 = .7176$
$b_3 = -.5005$
Sum = −0.7287

$c_1 = .3993$
$c_2 = -.2056$
Sum = .1937

$$IE = -174.94 + \sum_{i=1}^{3} b_i IE_{t-i} + \sum_{i=1}^{2} c_i RGDPBUS_{t-i} - .04YRAHEAD$$

$b_1 = -.9630$
$b_2 = .7540$
$b_3 = -.5143$
Sum = −.7233

$c_1 = .4128$
$c_2 = -.2143$
Sum = .1985

Richard W. Kopcke, "The Determinants of Business Investment: Has Capital Spending Been Surprisingly Low?" *New England Economic Review*, January/February 1993, pp. 3–31.

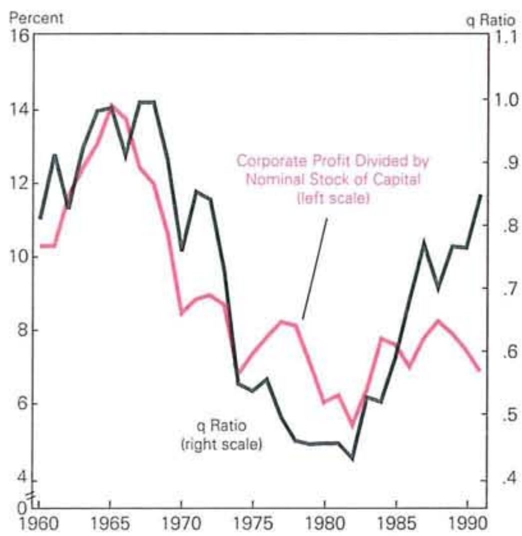
ERRATA

Three figures appeared with incorrect color keys in this article. The corrected figures are presented on both sides of this page.

Figure 2 (page 13)

Figure 2

Rate of Return on the Stock of Capital and the q Ratio (q Model)

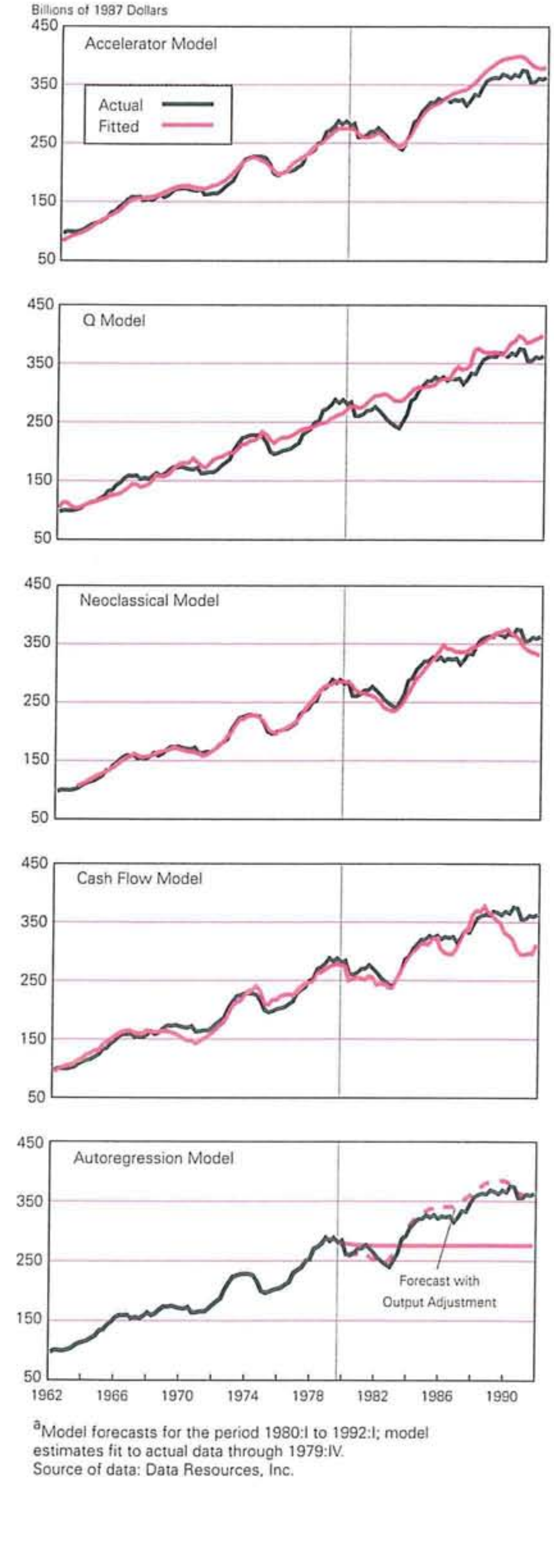


Source of data: Data Resources, Inc.

See over.

Figure 5 (page 21)

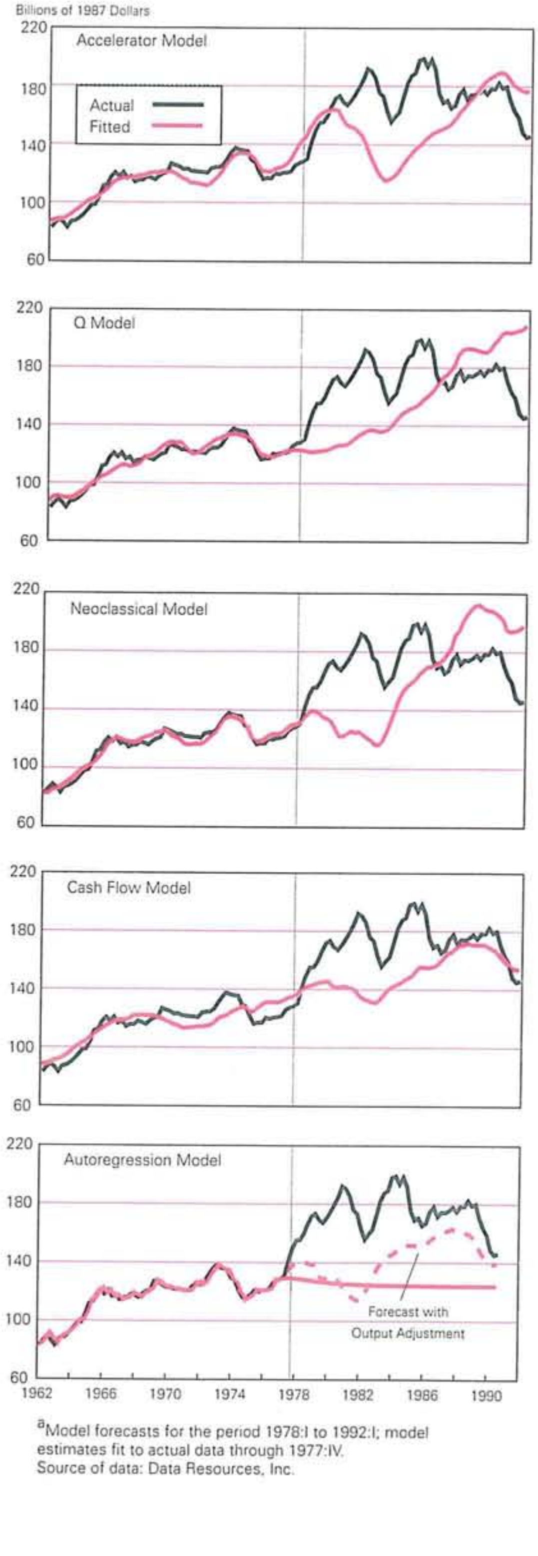
Actual Expenditures and Forecasts[a] of Investment in Equipment



[a]Model forecasts for the period 1980:I to 1992:I; model estimates fit to actual data through 1979:IV.
Source of data: Data Resources, Inc.

Figure 6 (page 23)

Actual Expenditures and Forecasts[a] of Investment in Structures



[a]Model forecasts for the period 1978:I to 1992:I; model estimates fit to actual data through 1977:IV.
Source of data: Data Resources, Inc.