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FACTORS INFLUENCING INVESTMENT COMMITMENTS AND REALIZATIONS

THE distributed-lag relation between investment commitments and realizations suggests the following procedure: Study the dependence of commitments on the economic factors that are believed to be important determinants of fixed-investment demand, and link the estimates of commitments thus obtained to subsequent realizations by the appropriate distributed-lag functions. However, although this is an elegant approach, it is not necessarily the most informative; it bypasses some antecedent questions and presupposes knowledge that is as yet lacking.

The procedure followed here consists of successive approximations; it is more tentative but is also less pretentious and potentially more instructive than the approach outlined above. It recognizes that the available measures of new investment commitments, such as the *OC* series, may not be adequate; tests are needed to see if these measures still significantly influence the realizations (such as *I*) in equations that also contain those "causal" factors that are supposed to codetermine investment. Since there is no general agreement based on tested knowledge about what precisely these factors are and how they are to be measured, it would seem prudent not to rely on a single specification of some particular type. To be helpful, data on investment commitments must have substantial *net* effects upon realizations; they must absorb most of the combined influence of the determinants of investment decisions and leave "unexplained" the elements that are due to later modifications of these decisions or to changes in the rate of their implementation. Of course, such data must therefore themselves be meaningfully related to the variables that are presumably shaping the decisions to invest.

A Regression Analysis of Investment Expenditures

Symptomatic and Causal Factors

Investment anticipations, like appropriations or orders and contracts for capital goods, are "symptomatic" factors—reflections of the firm's decisions to make the outlays—rather than "causal" factors which shape these decisions. Symptomatic relationships predict the behavior of the dependent variable but do not "explain" it analytically; causal relationships are supposed to explain as well as predict. For this reason, causal factors are generally viewed as superior to symptomatic ones. But the best equation using only causal variables may not provide the optimal forecast; symptomatic variables may improve the forecast and, if so, they should be used.[1]

The plans and expectations that govern business decisions are based on current and past values of some causal variables, but they typically include additional elements of judgment, which are supplied by the decision makers themselves and not by the available data. Hence, the causal variables, even if correctly specified, may fail to predict the outcome of economic decisions adequately, because the information they provide contains only projections of past values and misses the judgments about the future. The symptomatic or anticipatory data will presumably reflect this extra ingredient of "judgment."

Expectational variables may, however, fail to include some of the relevant information contained in the past and contemporaneous values of the causal factors. But this applies primarily to anticipations of events or processes which are largely beyond the control of the anticipator (e.g., to forecasts of sales of a competitive industry or firm or of GNP). It is not an important source of major difficulties for variables that reflect decisions over whose implementation the decision maker has considerable control and which are embodied in bona fide contracts that look into the future; and new investment orders, as well as capital appropriations, have essentially the characteristics of such variables. The forecasting errors may, in fact, be much less important in this case than errors of measurement. As noted before, perfect measures of investment orders and contracts, and of the temporal pattern of their

[1] See Arthur M. Okun, "The Predictive Value of Surveys of Business Intentions," *American Economic Review*, May 1962, p. 218.

execution, should in principle go far indeed to insure good predictions of investment realizations.

The subsequent course of events may, of course, diverge from the expectations which prevailed at the time a decision or action found expression in the symptomatic data. Firms would presumably modify their plans in response to such divergencies. Forecasts with both anticipated and realized values of causal variables may be able to allow for these reactions more or less efficiently. Ideally, one would want to specify and estimate the appropriate "realization functions" in Modigliani's sense.[2] However, little is known yet about how to integrate (rather than just combine) the two categories of factors in prediction.

It is often difficult to determine what is properly to be viewed as causal and what as symptomatic. One familiar difficulty is that a factor that seems causal may really stand in a derived rather than fundamental relation to the dependent variable.[3] Then, too, a variable that is symptomatic in one context may well be causal in another. For example, new orders received by producers of industrial machinery are symptomatically related to expenditures on investment in industrial machinery, but may be causally related to investment outlays of the machinery manufacturers.

Two sets of relationship are examined in this chapter with a view to evaluating the performance of both types of variables as determinants of investment in plant and equipment. The first employs series in current dollar values, the second uses data adjusted for price change, where appropriate.

Gross Relations with Selected Variables

Table 10-1 relates investment to several variables treated as independent and taken here one at a time. The regressions of investment expenditures (I) on the first three variables (which are excerpted from Table 9-1) illustrate symptomatic relationships. The others are presumably causal; they are broadly associated with the following hypotheses regarding the motivation of spending on plant and equipment:

[2] Cf. Franco Modigliani and Kalman J. Cohen, *The Role of Anticipations and Plans in Economic Behavior and Their Use in Economic Analysis and Forecasting*, Urbana, Ill., 1961.

[3] This is a basic distinction for economic relations, though its treatment in literature varies. The terms "derived" and "fundamental" are used as in James S. Duesenberry, "Income-Consumption Relations and Their Implications," in *Income, Employment, and Public Policy; Essays in Honor of Alvin H. Hansen*, New York, 1948, pp. 56–61.

Table 10-1
Simple Correlations of Plant and Equipment Expenditures on Selected Variables, 1949–61 and 1954–61

Indep. Var. Correlated with Plant and Equip. Expend. (*I*) and Period[a]	Lag of *I* Relative to Indep. Var. (qrs.) (1)	r (2)	$\bar{r}^2$ (3)	Stand. Error of Est. (bill. dol.) (4)
1. New investment orders and contracts (*OC*)				
1949–61	2	.918	.840	2.1
1954–61	2	.936	.871	1.3
2. First anticipations (A_1), 1949–61		.979	.957	1.1
3. New capital appropriations, manufacturing (*App*), 1954–61	3	.891	.789	2.5
4. Final sales, GNP minus net change in inventories (*FS*)				
1949–61	1	.887	.783	2.5
1954–61	1	.667	.427	2.7
5. Corporate profits after taxes (*R*)				
1949–61	1	.586	.331	4.3
1954–61	1	.748	.546	2.4
6. Corporate cash flow (retained earnings plus depreciation) (*CF*)				
1949–61	2	.919	.841	2.1
1954–61	2	.830	.678	2.0
7. Rate of capacity utilization in manufacturing (*CP*)				
1949–61	1	.071	.005	5.3
1954–61	1	.190	.036	3.6
8. Ratio of unfilled orders to sales, mfr. (*U/S*)				
1949–61	1	–.072	.005	5.3
1954–61	1	–.383	.147	3.4
9. Change in final sales (ΔFS)				
1949–61	1	.172	.030	5.1
1954–61	1	.337	.114	4.4
10. Change in corporate profits after taxes (ΔR)				
1949–61	1	.081	.007	5.4
1954–61	1	.116	.013	3.6

Source: Variable 1, Office of Business Economics–Dodge Corporation; variable 2, OBE–Securities and Exchange Commission; variable 3, National Industrial Conference Board; variables 4–6 and 8–10, OBE; variable 7, Frank de Leeuw, Federal Reserve Board.

[a] Regressions for 1949–61 are based on series of 50–52 quarterly observations; those for 1954–61, on 33 quarterly observations.

1. These outlays vary with the demand pressures on available productive capacities, according to the acceleration principle in its more flexible or the simplest rigid version. This accounts for the inclusion of the level and change of final sales (FS, ΔFS), the rate of capacity utilization (CP), and (U/S), the backlog-shipment ratio.

2. Business capital expenditures depend on internal funds of corporations (CF), which are preferred because of the risks attached to rising debt-earnings ratios or imperfections in the capital market.

3. Profits (R) are important because they generate profit expectations and may be usable as a proxy for the latter.[4] Changes in profits (ΔR) also reflect the changing cyclical relations between costs and selling prices, which are believed to influence the timing aspect of investment decisions. Moreover, profit changes are related to changes in the distribution of total profits between different industries and firms; that is, ΔR may serve as a proxy for the diffusion index of profits. A fall in the latter signifies that an increasing proportion of companies experience declining profits; when this happens in the late phase of expansion, investment may well be discouraged even though aggregate profits are still rising.[5]

Since these hypotheses are not necessarily mutually exclusive, the different variables will be tested jointly. At this point, however, we are concerned merely with the comparative performance of the anticipatory data as predictors of investment, not with the causal relationships as such; hence, no effort is made here to specify these relations in a more integrated and refined form. Some of the variables were chosen in part because the estimates for them were conveniently available or

[4] What undoubtedly counts most are the expected profits from contemplated investment projects, not expected profits from sales at large; and the two need not be related in any simple way.

[5] See Arthur F. Burns, *New Facts on Business Cycles*, Thirtieth Annual Report of the National Bureau of Economic Research, New York, May 1950; reprinted in Burns, *The Frontiers of Economic Knowledge*, Princeton for NBER, 1954, pp. 125–29. On the fluctuations in the diffusion of profits, see Thor Hultgren, *Cyclical Diversities in the Fortunes of Industrial Corporations* Occasional Paper 32, New York, NBER, 1950.

These are believed to be the most convincing arguments for inclusion of R and ΔR in the investment function, but others that have been offered should also be noted, partly because they complicate the situation. Thus R has aspects of a financial variable and is likely to be well correlated with CF. Kalecki used ΔR, arguing that "a rise in profits from the beginning to the end of the period considered renders attractive certain projects which were previously considered unprofitable and thus permits an extension of the boundaries of investment plans in the course of the period" (*Theory of Economic Dynamics*, London, 1954, p. 97). To the extent that profit change and output change are intercorrelated, the use of this factor also "corresponds roughly to the so-called acceleration principle" (*ibid.*, p. 100).

because they have been used by others in related work. Not represented here is the hypothesis that capital outlays depend on long-term interest rates, but these rates will be included later in regressions that use data adjusted for price changes.

Some clues as to which lags to use were found in recent reports that contain regressions of plant and equipment expenditures (I) on assorted variables. The calculations suggest that it is not difficult to obtain rather high correlations with I in various ways.[6]

It seemed desirable to include in the analysis some representation of capital utilization, but the available measures of capacity show major discrepancies. The selected series (CP) is an index of percentage capacity utilization for manufacturing, constructed by Frank de Leeuw. This is a seasonally adjusted series of quarterly ratios of the Federal Reserve Board index of manufacturing production to related estimates of manufacturing capacity.[7] Also included is the quarterly series of ratios of manufacturers' unfilled orders to sales (U/S), which was considered a proxy measure reflecting the relation of demand to capacity.

In terms of the gross measures of Table 10-1, I_t shows the closest correlations with corporate cash flow (CF_{t-2}) and final sales (FS_{t-2}), a weaker association with after-tax profits (R_{t-1}), and positive but quite low correlations with ΔFS and CP. For the relations between I_t and $(U/S)_{t-1}$ and between I_t and ΔR_{t-1}, the r's are both very low and negative. However, as shown later, when these variables are used jointly rather than individually their effectiveness as factors influencing I_t is considerably different. What Table 10-1 does bring out clearly is that the anticipatory data (lines 1–3) are in general better predictors of capital outlays than the causal variables (lines 4–10); and this finding will not be refuted by the multiple-regression tests to follow.

Fixed-investment expenditures show a high degree of inertia over

[6] See, e.g., Jack Robinson and Albert T. Sommers, "How Good Is the Capital Goods Market?," *Conference Board Business Record*, March 1960, pp. 12–17. The authors report that correlations of I_t with new orders of all manufacturers, N_{t-i}, range from .82 (for $i = 0$) to .94 (for $i = 2, 3$). The correlations of I_t with corporate cash flow, C_{t-i}, range from .83 (for $i = 0$) to .91 (for $i = 2$). The lags considered vary from zero to four quarters. The correlation figures were read off a graph and are therefore approximate.

[7] Three series are used to develop these estimates: (1) the Commerce estimates of manufacturers' fixed capital stock in 1954 dollars; (2) the McGraw-Hill index of manufacturing capacity; and (3) McGraw-Hill "rate-of-operations" figures (available since 1955). Since it is judged that the sources of error in these measures are sufficiently different in each, a less biased estimate can be obtained by combining them. See *Measures of Productive Capacity*, Subcommittee on Economic Statistics of the Joint Economic Committee, 87th Cong., 2nd sess., May 1962, pp. 127–29.

the short run, in the sense that the value of I in the current quarter is closely associated with its value in the preceding quarter. The coefficient of autocorrelation for the quarterly seasonally adjusted values of I is .975. This is a higher r than any other in the table except that for A_1.

Multiple Regressions with Symptomatic and Causal Factors

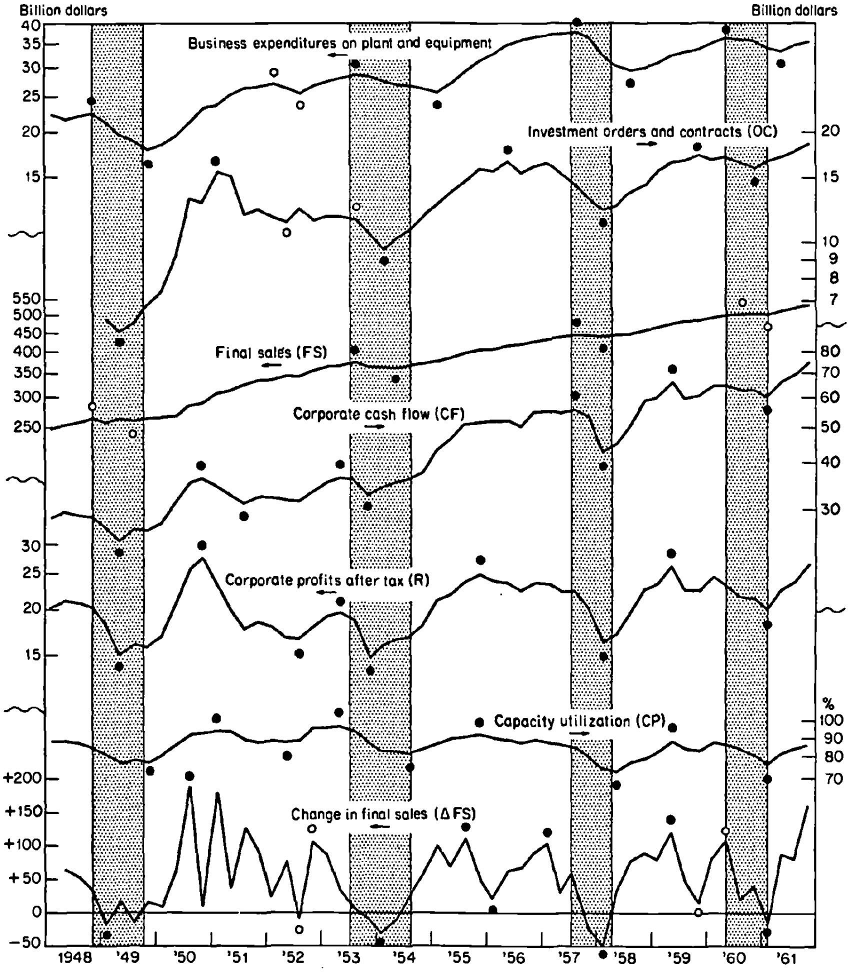
Multiple regression studies of economic time series encounter certain typical problems because of the presence of common trends and cycles. Chart 10-1 helps to uncover some probable sources of such problems in the data used here. The correlation between I and FS appears to be accounted for largely by the common upward trend in these series. The relative cyclical movements in FS are much milder than those in I, which is a well-known phenomenon; they are also quite different in other respects, e.g., the contractions of FS are much shorter and end earlier. Both trend and cyclical movements are pronounced in CF, and they combine to produce the marked correlation between this series and I. The cyclical movements in R parallel those in CF and are even stronger, but R does not drift upward significantly in the period covered and so its correlation with I is lower. To keep the multicollinearity problem down to manageable size, these two variables are used as alternatives in our regressions, that is, they do not appear together in any single equation. Finally, by definition, the capacity utilization factor (CP) can have no rising secular trend, while investment in a growing economy must have it. A given level of the CP series, therefore, would correspond over time to increasing levels of I, and this difference in trends may be a real stumbling block if CP is used as a factor in our regressions.[8]

The use of single-equation models implies that the chain of influence runs only from the series used to represent the independent variables to the dependent variable, in this case I. The presence of significant influences running in the opposite direction would raise the question of the single-equation bias. The present exploration tries to steer clear of this issue mainly by avoiding the simultaneous relations and using only the lagged or "predictive" ones.

Regressions of mixed (symptomatic-causal) type are assembled in Table 10-2. Here sets of two or three causal variables are used and

[8] This difficulty is avoided by the use of a "capital requirements" series instead of the (related) capacity utilization figures. This point will be taken up in the next section of this chapter.

Chart 10-1
Selected Series Used in Regression Analysis of Orders and Outlays for Capital Goods, Quarterly, 1948–61



Note: Shaded areas represent business cycle contractions; unshaded areas, expansions. Dots identify peaks and troughs of specific cycles; circles, minor turns or retardations. All but the bottom curve are plotted against ratio scales.

Source: See Table 10-1.

Table 10-2
Regressions for Plant and Equipment Expenditures, Quarterly Data, 1949–61 and 1954–61

Regress. No.[a]	Constant Term	Regression Coefficients[b]								R	$\bar{R}^2$	Stand. Error[c]
		OC_{t-2}	A_1	App_{t-3}	FS_{t-1}	R_{t-1}	CF_{t-2}	CP_{t-1}	$(U/S)_{t-1}$			
Ia	−6.203	0.705			.040	.043[d]		.118		.953	.899	1.700
	(5.553)	(0.185)			(.008)	(.101)		(.061)				
Ib	−2.157		.687		.007	.213		.051		.990	.978	0.782
	(2.310)		(.045)		(.004)	(.045)		(.027)				
Ic	−3.773			3.527	.044	.099[d]		.092[d]		.965	.926	1.013
	(5.764)			(0.355)	(.006)	(.118)		(.063)				
IIa	−1.437	0.620			.039	.258			0.603	.953	.900	1.694
	(3.231)	(0.207)			(.007)	(.121)			(0.298)			
IIb	−0.450		.665		.007	.306			0.328	.991	.980	0.748
	(1.113)		(.044)		(.003)	(.040)			(0.114)			
IIc	−13.972			2.808	.055	.389			2.230	.979	.954	0.801
	(4.268)			(0.329)	(.005)	(.075)			(0.498)			
IIIa	−7.551	0.526			.026		.198	.142		.956	.905	1.646
	(5.391)	(0.206)			(.011)		(.111)	(.056)				
IIIb	−4.483		.614		.0007[d]		.159	.109		.988	.974	0.869
	(2.459)		(.052)		(.006)		(.052)	(.025)				
IIIc	−5.672			3.482	.042		.056[d]	.121		.965	.925	1.021
	(5.064)			(0.433)	(.013)		(.115)	(.048)				
IVa	0.711	0.344[d]			.002[d]		.485		0.939	.957	.910	1.612
	(2.087)	(0.235)			(.011)		(.323)		(0.323)			
IVb	3.838		.619		−.012[e]		.271		0.345	.984	.966	0.986
	(1.168)		(.069)		(.006)		(.072)		(0.072)	(.168)		
IVc	−3.336			3.189	.032		.236		1.305	.963	.922	1.044
	(4.719)			(0.482)	(.012)		(.114)		(0.588)			

		OC_{t-2}	A_1	App_{t-3}	ΔFS_{t-1}	ΔR_{t-1}	CP_{t-1}	$(U/S)_{t-1}$			
Va	14.900	1.582			−.244 [d,e]		−.069 [d,e]		.922	.840	2.138
	(4.989)	(0.099)			(.682)		(.059)				
Vb	0.745		.816		.060		.053		.984	.967	0.999
	(2.400)		(.022)		(.031)		(.028)				
Vc	38.737			4.918	.282		−.208 [e]		.820	.651	2.190
	(7.135)			(0.703)	(.093)		(.092)				
VIa	10.634	1.572			−.057 [d,e]			−0.329 [d,e]	.922	.841	2.133
	(1.674)	(0.098)			(.061)			(0.260)			
VIb	5.438		.814		.089			−0.059 [d,e]	.983	.964	1.036
	(0.854)		(.022)		(.029)			(0.126)			
VIc	32.392			4.640	.060 [d]			−2.565 [e]	.874	.749	1.857
	(2.501)			(0.551)	(.081)			(0.597)			
VIIa	15.518	1.610				.261	−.083 [e]		.927	.850	2.072
	(4.415)	(0.097)				(.147)	(.052)				
VIIb	−0.948		.824			.197	.073		.985	.968	0.950
	(2.111)		(.021)			(.067)	(.023)				
VIIc	32.628			5.088		.246 [d]	−.124 [d,e]		.764	.556	2.467
	(7.658)			(0.835)		(.245)	(.098)				

[a] Roman numerals refer to sets of independent variables other than the symptomatic ones (OC, A_1, and App), as follows: Set I—FS, R, CP; set II—FS, R, U/S; set III—FS, CF, CP; set IV—FS, CF, U/S; set V—ΔFS, CP; set VI—ΔFS, U/S; and set VII—ΔR, CP. In addition, letter a denotes regressions containing the variable OC; b, variable A_1; and c, variable App (in addition to the above sets of the other variables). Regressions with OC and A_1 cover 1949–61 (50–51 quarterly observations); those with App cover 1954–61 (33 quarterly observations).

[b] See Table 10-1 for explanation of the symbols. Subscripts $(t-i)$ identify the lead of i quarters with which the given series is taken relative to the dependent variable, I_t. Standard errors of the coefficients are given underneath in parentheses.

[c] Adjusted for degrees of freedom (unbiased); in billions of dollars.

[d] Not significant at the 5 per cent level. Coefficient less than 1.7 times its standard error. (One-sided t test is applied because the signs expected of the regression coefficients are stated beforehand.)

[e] Sign is "wrong," i.e., contrary to expectation.

each set is combined alternatively with OC_{t-2} or A_1. This results in pairs of comparable equations for 1949–61 such as Ia-Ib, IIa-IIb, etc. We review also the combinations of the same variables with App_{t-3}, but these regressions (Ic, IIc, etc.) apply to the period 1954–61 and thus are favored by the fact that the period since 1954 yields generally better statistical explanations of I than the longer period since 1949.

Consistent with Okun's findings, the regressions featuring A_1 yield in each case a higher $\bar{R}^2$ and a lower SE than the corresponding equations with OC_{t-2} or App_{t-3}. In most instances, the same criteria also suggest that better results are obtained with *App* than with *OC*, but this is not a conclusive comparison because of the difference, noted above, between the periods covered.[9]

Except for cash flow (*CF*), which is taken with a two-quarter lead, the causal variables are all applied with a one-quarter lead relative to *I*. (The leads chosen are those that maximize the simple correlations with *I*, see Table 10-1.) *CF* is important in all but one of the six regressions in which it appears. However, this series is highly correlated with some of the other independent variables, notably with final sales (*FS*), which fails whenever it is included along with *CF*. The profits variable (*R*) is less closely associated with the other factors, and it works somewhat better than *CF* in combination with several of them.[10]

The capacity utilization and the backlog-shipment ratios (*CP* and *U/S*) are used as alternates only (like *CF* and *R*). *U/S* proves significant in each case and *CP* in each except one; their coefficients are all positive. It is worth recalling that neither factor, when taken alone, shows significant positive correlations with *I* (Table 10-1). All in all, *U/S* appears to have a certain advantage over *CP* (compare Table 10-2, regressions Ia-IIa, IIa-IIIa, IIIa-IVa, etc.).

The regressions which use the variables ΔFS or ΔR (sets V and VII) are on the whole worse than those which use *FS* and *R* or *CF* (sets I–IV; note that the other factors are common to both groups). The former equations yield lower values of $\bar{R}^2$ and higher *SE*'s, and the regression coefficients are more frequently insignificant or "wrong" in

[9] It may be recalled that, for 1954–61, the simple correlations between *I* and *OC* are substantially higher than those between *I* and *App* (see Table 10-1).

[10] For *R*, the highest correlations are with *OC* (.626), A_1 (.471), and *FS* (.448); for *CF*, those with *FS* (.952), A_1 (907), and *OC* (.883). Note that *CF* is used in equation sets I and II of Table 10-2 and *P* in sets III and IV; otherwise the pairs of equations Ia-IIIa, Ib-IIIb, . . . , IIa-IVa, IIb-IVb, etc., contain the same variables, so the roles of *CF* and *R* can be directly compared.

sign. However, the weakness of these equations may reflect errors of omission more than of commission. The coefficients of ΔFS are positive and significant, except in the equations with OC (Va and VIa). The coefficients of ΔR are positive and significant in all cases. It is possible that a different lag structure would considerably improve the performance of these variables. Even with simple lags, their use in combination with A_1 and CP gives good results (Vb and VIIb).

In general, the symptomatic variables contribute much more than the causal ones to the over-all correlations. It is possible that a better selection of the causal factors would reverse this result. But there is considerable evidence here that this is unlikely, and the same is indicated by the analysis to follow, which is an effort to improve the data inputs and specifications used. This conclusion is also supported by other exploratory work in the area.[11]

Data Related to Investment in Real Terms

In another round of trial regressions for plant and equipment expenditures, series expressed in dollars of constant purchasing power were used instead of the series in current prices. Asterisks denote deflated variables. The investment orders series was adjusted by means of the implicit deflator for producer durable equipment (one of the price series used to deflate the GNP components). The construction contracts series was adjusted separately by means of the deflator for nonresidential, nonfarm construction. The deflated series were added to obtain OC^*. A weighted combination of the two price deflators was also used to adjust the plant and equipment expenditures and the cash flow and profit series.[12]

Fabricated metal products were this time excluded from the aggregate of investment orders. The net result should be a better approximation to a measure of such orders, as noted in Chapter 9.

[11] Okun ("Predictive Value of Surveys," pp. 223–24) finds that the predictive value of first anticipations is "significantly enhanced" by the addition of either the change in GNP or the change in corporate profits (SE is \$0.95 billion when A_1 alone is used, \$0.85 billion when either ΔGNP or ΔR is used as well in the regression for I). Even "a shameless amount of data mining," Okun reports, failed to produce a "causal explanation" of plant and equipment outlays that would match these regressions.

[12] The weights (0.59 for the producer durables equipment index and 0.41 for the nonresidential construction index) were determined from the 1951–59 quarterly data.

The price indexes used as deflators are based on prices of inputs to the equipment or construction industries rather than on prices of the outputs of these industries. The latter would be preferable but are in general not available.

Three new variables were added to the others in these experiments: the "capital requirements" (CR^*); the real capital stock (K^*); and the interest rate (i). The data on capital stock relate to manufacturing and are net of depreciation. They were computed by Jorgenson, using the end-of-year figures for 1948 and 1960 from the OBE "Capital Goods Study" (unpublished).[13] Interest rates are represented by Moody's composite average of yields on corporate bonds (Baa through Aaa ratings).[14]

A "capital requirements" series designed to estimate "the constant-dollar volume of projects which will bring capacity into an optimum relationship to output" has been compiled by de Leeuw.[15] Capital requirements were conceived as consisting of projects needed to: (1) adjust capacity optimally to present output; (2) take account of expected changes in output; and (3) replace the worn-out capital stock. Component (1) was estimated on the assumption that manufacturers prefer a rate of operations of 90 per cent. Our CR^* series was computed according to the procedure described by de Leeuw, but with some modifications in the estimation of (2) and a different measure of (3).[16]

The deflated series are shown in Chart 10-2. They resemble the corresponding series in current dollars with strongly reduced trends (Chart 10-1). The division by the rising price indexes shifts some of the peaks to later dates and some of the troughs to earlier ones. Of the

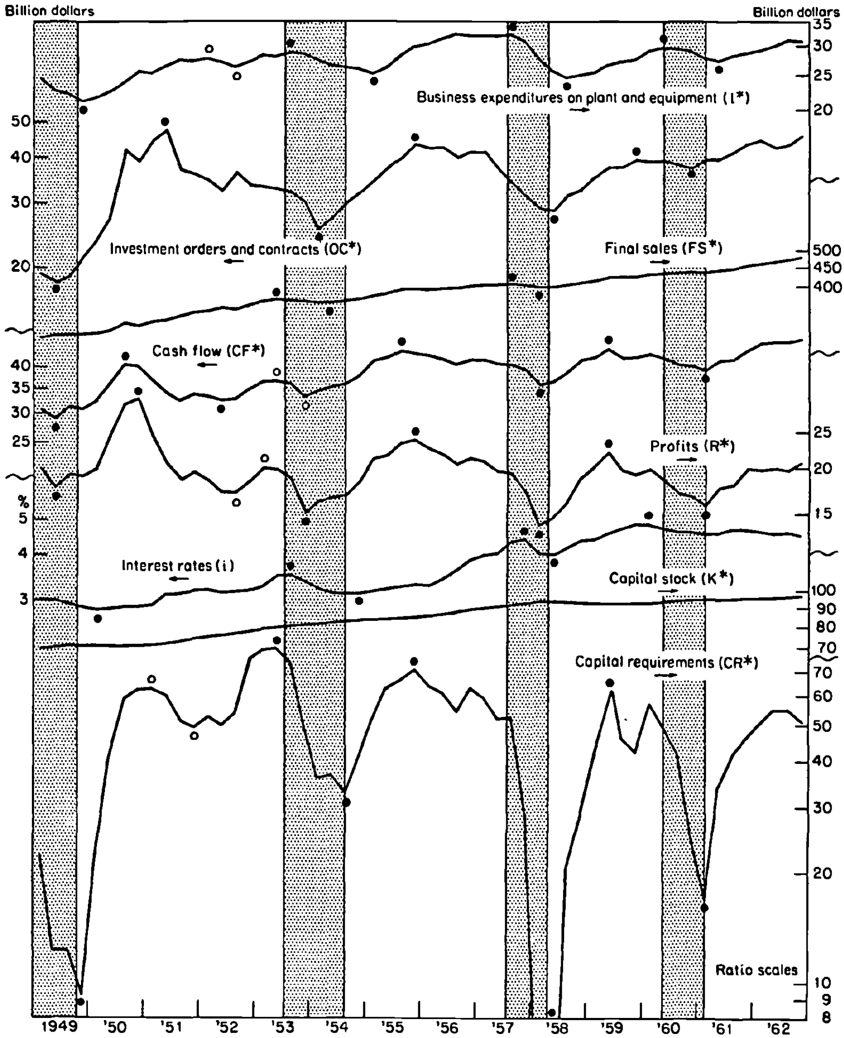
[13] The method of computation is described in Dale W. Jorgenson, "Capital Theory and Investment Behavior: Statistical Supplement," mimeographed, pp. 55–61. The data have been adjusted for seasonal variation by Jorgenson (*ibid.*, pp. 148 ff. and pp. 176 ff.).

[14] No attempt was made to cope with the problem of measuring price expectations and their effects in the present context; hence a *real-interest* variable was not used (see Table 8-8 and the accompanying text).

[15] Frank de Leeuw, "The Demand for Capital Goods by Manufacturers: A Study of Quarterly Time Series," *Econometrica*, July 1962, pp. 407–23.

[16] De Leeuw computes (2) under the assumption that the expected rate of increase in output is 4 per cent per year. He thus adds $C_2 = 0.04$ to $C_1 = (1.111Z - CP)/CP$, where Z is the output index and CP the capacity index (note that a rate of operations of 90 per cent implies that capacity is equal to 111.1 per cent of output). The total $(C_1 + C_2)$ is then multiplied by the constant-dollar value of the capital stock for each quarter. De Leeuw uses Commerce estimates of the constant-dollar value of capital stock, interpolated quarterly; I use the related estimates by Jorgenson (see note 13). Also, I find that the assumption of a projected growth rate of 4 per cent would imply an average gestation period of about four years, if CR^* is to be positive throughout 1949–62. A shorter gestation period, perhaps three years, seems more appropriate; this, however, would imply a higher expected rate of growth in output of about 5.12 per cent. The higher rate (or shorter gestation period) results in a higher *level* of the CR^* series, but it does not affect its pattern of changes. As for replacement (3), I again use Jorgenson's estimates based on his capital-stock figures and the assumption that the rate of the wearing-out of capital is proportional to the rate of output. De Leeuw uses his own estimates. See *ibid.*, pp. 412–13.

Chart 10-2
Selected Series Relating to Investment in Constant Dollars, Quarterly, 1949–62



Note: Shaded areas represent business cycle contractions; unshaded areas, expansions. Dots identify peaks and troughs of specific cycles; circles, minor turns or retardations.

Source: See Table 10-1 and text.

new variables, i shows a marked trend in the fifties, but also considerable declines in 1953–54, 1957–58, and in the early sixties. Plotted on the logarithmic scale, K^* shows an almost linear trend through 1957 (with a retardation in 1950), and a definite slowdown in 1958–62. CR^* is dominated by very large cyclical fluctuations; its trend is, if anything, downward in the decade since 1953.

Regressions with Constant-Dollar Series

Deflated orders-contracts (OC^*) taken alone "explain" nearly 50 per cent of the variance of real capital outlays lagged one quarter and nearly 60 per cent when a lag of two quarters is applied. The best result ($\bar{R}^2 = .626$) is obtained with a three-quarter lag of expenditures relative to orders, in real terms. In the multiple regression of I^* on OC^*_{t-i} ($i = 1, 2, 3$), only OC^*_{t-3} is significant at least on the 5 per cent level. The contribution to $\bar{R}^2$ of OC^*_{t-4} is very small, and it is clear that multicollinearity precludes gains from extensions of this distributed-lag approach. These results are generally worse than those obtained for the series in current dollars, and the same applies to the Koyck-type equations, in which the coefficients of the OC^* terms are rather uncomfortably low relative to those of I^*_{t-1} (though they are significant for OC^* terms with short leads). Not only are the fits poorer, but the implications of the regression estimates are rather awkward, since the effect on expenditures of orders-contracts would here appear to be considerably smaller yet also substantially more sluggish.

It is quite possible that the deflation procedures introduce large additional errors of measurement that affect our estimates. In any event, there is no reason to attach much importance to measurements in constant-dollar terms as far as the relations with symptomatic variables only are concerned. These relations are interesting from the forecasting rather than the analytical point of view. Use of values in current prices is more convenient here and apparently also more rewarding. It is only when some causal variables are included that the use of values in base-year prices is indicated.

It may be added that the correlogram of I^* shows a steep decline: I^*_t is highly correlated with I^*_{t-1}, considerably less with I^*_{t-2}, and but weakly with I^*_{t-3}. While OC^* performs worse than the autoregressive factor in predicting investment outlays over a period as short as one quarter, it performs better than that factor over longer spans, say, of two or three quarters. In a regression of I_t^* on OC_{t-3}^* and I_{t-3}^*, for example, the statistical significance of the former factor is high, that of the latter very low or doubtful.

Taken either with a two-quarter or a three-quarter lead, OC^* proves likewise highly significant when used in combination with the presumed causal determinants of I^*, whether or not the autoregressive factor is also included. This is shown by the six regression equations in Table 10-3 and the corresponding simple and partial correlation coefficients in Table 10-4. OC_{t-3}^* comes out somewhat better than OC_{t-2}^* in these estimates.

Of the causal variables, which are all once-lagged, "capital requirements" (CR^*) definitely stands out, judging by the t tests and partial r's (Tables 10-3, column 5, and 10-4, column 4). However, capital stock (K^*) retains significance in four of the regressions shown (Table 10-3, column 6), even though CR^*, which involves a comparison of the available with the required capacity, should incorporate a substantial part of the influence of K^*. The effect of the latter factor remains positive and significant when FS^*, a proxy for the "demand-for-output" variable, is added. Demand for investment to expand capacity would be expected to depend negatively on the capital stock and positively on the demand for output. But this "flexible accelerator" or general "capacity effect" should be largely captured by the factor CR^*. The coefficient of K^*, therefore, presumably represents in the main the effect of the size of the capital stock upon the replacement component of gross investment, and perhaps also some residual trend influences.[17]

The interest variable, i_{t-1}, has throughout the expected negative sign and is in most cases significant (Table 10-3, column 7). It is worth pointing out that the simple correlations between the interest rate and lagged investment expenditures are positive (Table 10-4, column 6). The contributions of cash flow (CF_{t-1}^*) are small or of doubtful significance. The partial correlations are here decidedly lower than the simple ones (Table 10-4, column 7).

The Durbin-Watson statistics indicate a strongly positive autocorrelation of the residuals in those cases where no autoregressive term

[17] The replacement demand for capital goods should vary positively with the capital stock (given its composition by age of equipment, etc.). Nevertheless, for total gross investment, the negative effect can be expected to prevail. As will be seen later, the coefficient of K^* is indeed negative when calculated for what must be the more appropriate relationships, namely, those with OC^* rather than I^* as the dependent variable. See below, in the section "Estimates for Constant-Dollar Data."

Table 10-3
Regressions for Plant and Equipment Expenditures in Constant Dollars, 1949–62

Regression No.[a]	Constant Term (1)	Regression Coefficients[b] OC^*_{t-2} (2)	OC^*_{t-3} (3)	I^*_{t-1} (4)	CR^*_{t-1} (5)	K^*_{t-1} (6)	i_{t-1} (7)	CF^*_{t-1} (8)	$\bar{R}^2$ (9)	Stand. Error of Estimate (bill. dol.) (10)	Durbin-Watson Statistic[c] (11)
1a	5.190	.173			.064	.230	−1.577		.833	1.077	0.781[d]
	(1.958)	(.033)			(.011)	(.041)	(0.532)				
1b	5.374		.188		.069	.220	−1.582		.865	0.911	0.747[d]
	(1.766)		(.024)		(.008)	(.036)	(0.582)				
2a	2.502	.065		.544	.044	.098	−0.641		.930	0.699	1.618[e]
	(1.312)	(.025)		(.067)	(.007)	(.031)	(0.364)				
2b	3.221		.075	.476	.049	.108	−0.705		.922	0.692	1.184[e]
	(1.390)		(.027)	(.080)	(.007)	(.033)	(0.372)				
3a	2.166	.053		.597	.034	.056[f]	−0.526[f]	.076[f]	.932	0.688	1.791[e]
	(1.307)	(.026)		(.073)	(.004)	(.040)	(0.364)	(.047)			
3b	2.970		.076	.528	.033	.048[f]	−0.611	.111	.931	0.653	1.508[e]
	(1.314)		(.025)	(.078)	(.009)	(.039)	(0.353)	(.043)			

[a] Set 1 excludes and sets 2 and 3 include the autoregressive factor I^*_{t-1}. Set 2 excludes and set 3 includes CF^*_{t-1}. Regressions 1a, 2a, and 3a contain OC^*_{t-2}; regressions 1b, 2b, and 3b contain OC^*_{t-3}. The former are based on series of 53, the latter on series of 52, quarterly observations.

[b] See text for explanation of the symbols. Subscripts identify the lead, in quarters, with which the given series is taken relative to the dependent variable, I^*_t. Standard errors of the coefficients are given beneath in parentheses.

[c] $d = \Sigma(u_t - u_{t-1})^2/\Sigma u^2$, where u_t is the estimated least-squares residual for the given regression.

[d] Indicates strongly positive autocorrelation of the residuals.

[e] See text on the limitations of the Durbin-Watson statistic in these cases.

[f] Not significant at the 5 per cent level. Coefficient is less than 1.7 times its standard error. (One-sided t test is applied because the signs expected of the regression coefficients are stated beforehand.)

Table 10-4
Simple and Partial Correlation Coefficients for Regressions for Plant and Equipment Expenditures in Constant Dollars, 1949–62

Regression No.[a]	Coefficients of Correlation[b] Between I_t^* and						
	OC_{t-2}^* (1)	OC_{t-3}^* (2)	I_{t-1}^* (3)	CR_{t-1}^* (4)	K_{t-1}^* (5)	i_{t-1} (6)	CF_{t-1}^* (7)
	PARTIAL CORRELATION COEFFICIENTS						
1a	.606			.653	.629	−.393	
1b		.746		.772	.669	−.456	
2a	.354		.766	.651	.419	−.249	
2b		.383	.659	.712	.437	−.269	
3a	.292		.770	.480	.199	−.208	.232
3b		.409	.710	.477	.182	−.250	.361
	SIMPLE CORRELATION COEFFICIENTS						
	.807[c]	.796[d]	.925[c]	.608[c]	.485[c]	.397[c]	.628[c]

[a] For identification, see Table 10-3, note a.
[b] See text for explanation of symbols. Subscripts identify the lead, in quarters, with which the given series is taken relative to the dependent variable, I_t^*.
[c] Based on the 53 observations used in the regressions with OC_{t-2}^* (1a, 2a, 3a).
[d] Based on the 52 observations used in the regressions with OC_{t-3}^* (1b, 2b, 3b).

is included (Table 10-3, column 11). Where such terms (here I_{t-1}^*) are used, they appear to absorb most of that autocorrelation but the d test is then known to be biased and therefore inapplicable in any strict sense (see Chapter 5).

The other factors considered, that is, FS^*, ΔFS^*, R^*, and ΔR^*, add virtually nothing to the goodness of the fit when taken together with the other variables.

To sum up, these results indicate again that the constructed series on fixed-investment commitments, for all its undoubted weaknesses, is significant in the regression analysis of investment expenditures, even when other factors are put into the equations. Its effect is decidedly weaker than that of the autoregressive term I_{t-1}^*, but the serial dependence of expenditures may itself be mainly the reflection of a distributed-lag process linking the later stages of investment to previous commitments.

The effects on investment expenditures of causal variables should be relatively weak in equations that include investment commitments.

The regressions in constant dollars, which are probably better specified than the preceding current-dollar regressions and are also less affected by the common-trends difficulty, show that these effects are indeed generally weak. Nevertheless, the significant contribution of some variables, notably CR^*, may leave one uneasy: They can well be understood as influencing investment decisions but hardly as intervening in the period after the contracts have been placed with only a short lead over expenditures.

I suspect that technical factors are mainly responsible for this intervention, namely, the various proxy and echo effects due to the autocorrelation and intercorrelation of the independent variables. These are difficult to eliminate. Ideally, one would wish to distinguish two groups of factors in an equation for plant and equipment expenditures: (1) those influencing decisions; and (2) those influencing the transformation of orders into expenditures. The joint impact of (1) would presumably in large part be reflected in the behavior of orders. The impact of (2) should mainly show up in changes in the rate at which the investment projects are implemented. Yet it is uncertain how well these two sets can be separated and quantified. Factors which influence capital outlays with relatively long lags, by shaping investment decisions, may also be affecting the process by which the decisions are carried out. In this role, they would then also be influencing outlays with shorter lags.

An Approach to Investment-Order Analysis

Selected Factors Relating to New Investment Commitments

The causal variables suggested by the theory of the demand for capital goods apply primarily to investment commitments rather than to expenditures. This is because the theory concerns the decisions that set the process in motion, and these are expressed relatively promptly and directly in orders and contracts which commit money capital. Outlays, however, trail investment decisions and orders, often by long and possibly complex lags.

Realized investment, of course, depends not only on demand but also on supply conditions for capital goods. On the demand side, the volume of planned additions to the stock of machinery and structures is subject in a high degree to the control of the firms which decide upon the new investment projects. However, these firms can generally only influence, not directly control, the supply flow of the goods they demand. In a boom, for example, they may order in the aggregate a larger volume of capital equipment than can be supplied with the available resources within the periods normally required for production and delivery or installation. In this case, prices of the goods and services involved are likely to rise, thereby discouraging some new investment demand in its early, controllable phase. For the projects already under way, however, the main effect will be to slow down their execution. New investment orders and contracts will run at peak rates during a relatively short period (as, e.g., early in the Korean War, 1950–51), but production in response to these orders will only gradually attain high levels and may continue rising slowly at high rates of capacity utilization for a considerable time (as in 1951–53). Capital outlays will then follow a course similar to that of production. The general phenomena of order-backlog accumulation and production smoothing are most pertinent in the present context, since it is the capital goods that are typically produced to advance orders, often in time-consuming multiphase operations.[18]

These considerations suggest that in principle it should be better to use new capital appropriations or orders in statistical demand functions for capital goods than to use expenditures. Commitments data should help to deal with the identification problem, since they are more nearly representative of investment demand, while outlays bear a closer relationship to production or supply. In practice, to be sure, caution is needed in the application of these data because of their considerable limitations. Accordingly, the question now asked is simply whether the

[18] James Duesenberry notes that "investment moves as though it were being backlogged in the years in which investment opportunities are very large and released in later years" (*Business Cycles and Economic Growth*, New York, 1958, pp. 87–89). He attributes this behavior largely to limitations on the supply of money capital that force some firms to restrict or delay their investment and believes that other factors such as shortages of capital goods and engineering staffs are on the whole less important. In particular, referring to the 1953–54 recession, Duesenberry argues that "investment continued at high levels" and that this cannot be due to "the completion of projects undertaken in earlier years." But the figures he himself quotes show that investment expenditures declined only 12 per cent, while orders and contracts declined about 23 per cent or nearly twice as much, which surely suggests that work on orders accumulated in the recent past played a considerable stabilizing role in this episode. Of course, it could still be true that the financial factors stressed by Duesenberry are important in the determination of investment decisions and that they help to maintain these decisions at high levels during recessions. To test this, the appropriate relations for study would be those between measures of these factors and investment appropriations or commitments.

factors already introduced in the analysis of expenditures could, when taken with different timing, make significant contributions to a statistical explanation of the composite of investment orders and contracts.

Table 10-5 shows the results of correlating *OC* with each of several series in current dollars, without lags and with lags of one to three quarters. The highest of these correlations are with *CF*, *FS*, and *R*. Those with *App* and ΔFS are considerably lower, and the others are very low and in a few instances negative.

The correlation between OC_t and OC_{t-1} ($r^2 = .88$) is the highest in the table. It should be noted, though, that the corresponding autocorrelation coefficient for investment expenditures is significantly higher still ($r^2 = .951$).

Investment orders and contracts move early in the business cycle, leading rather than lagging behind most of the related processes. In Table 10-5, the assumption of simultaneous timing yields higher correlations than the assumption of quarterly lags of *OC*, and lengthening the lag works systematically to reduce the correlations. However, the differences between the results for simultaneous relations and one-quarter lags tend to be small. Perhaps monthly regressions would provide more convincing evidence of short lags if the data were available and workable in this form.

In Tables 10-1 and 10-2, lags of one quarter were assumed for investment expenditures relative to most of the "causal" variables. The present results suggest longer lags, at least of the order of those separating expenditures from investment commitments (which, as shown earlier, equal probably two to three quarters, on the average).

In multiple regressions with discrete lags, corporate profits, and cash flow (not used simultaneously) have apparently strong effects upon *OC* (Table 10-6, regressions A1–A8). The backlog-sales ratios show surprising strength when combined with profits. The coefficients of final sales are (as in the equations for expenditures) either not significant or "wrong" in sign when cash flow is included.

The multiple correlation coefficients all exceed .9 and, when squared, suggest that from 84 to 92 per cent of the variance of *OC* can be "explained" with the aid of the few selected variables. According to the standard errors of estimate and the $\bar{R}^2$ coefficients, the best equation in this group is A6 [with FS_{t-2}, R_t and $(U/S)_t$]. Of the subgroup of regressions using lagged variables only, the best ones are A4 [with CF_{t-1} and $(U/S)_{t-1}$] and A2 [with R_{t-1}, $(U/S)_{t-1}$, and FS_{t-2}].

Table 10-5
Simple Correlations [a] of Investment Orders and Contracts (*OC*) with Selected Variables, 1949–61

Indepen. Var. Correlated with *OC*	Lag of *OC* Relative to Indepen. Var. (qrs.) (1)	r (2)	$\bar{r}^2$ (3)	Stand. Error of Est. (bill. dol.) (4)
1. FINAL SALES (*FS*)				
a	0	.828	.679	1.810
b	1	.805	.641	1.913
c	2	.782	.603	2.010
d	3	.765	.577	2.078
2. CORPORATE PROFITS AFTER TAXES (*R*)				
a	0	.777	.595	2.029
b	1	.761	.572	2.090
c	2	.644	.403	2.465
d	3	.478	.193	2.866
3. CORPORATE CASH FLOW (*CF*)				
a	0	.894	.795	1.444
b	1	.889	.786	1.477
c	2	.850	.717	1.697
d	3	.795	.625	1.955
4. RATE OF CAPACITY UTILIZATION, MANUFACTURING (*CP*)				
a	0	.216	.027	3.147
b	1	.142	.020 [b]	3.191
5. RATE OF UNFILLED ORDERS TO SALES, MANUFACTURING (*U/S*)				
a	0	−.102	.010 [b]	3.207
b	1	−.158	.005	3.183
6. CHANGE IN FINAL SALES (ΔFS)				
a	0	.425	.165	2.847
b	1	.398	.142	2.957
c	2	.286	.064	3.089
d	3	.199	.021	3.159
7. CHANGE IN CORPORATE PROFITS AFTER TAXES (ΔR)	0	−.076	.006 [b]	3.086
8. NEW CAPITAL APPROPRIATIONS (*App*)				
a	0	.549	.287	2.007
b	1	.536	.273	2.018
9. INVESTMENT ORDERS AND CONTRACTS	1	.940	.881	1.059

Source: Variables 1–3 and 5–7, Office of Business Economics; variable 4, Frank de Leeuw, Federal Reserve Board; variable 8, National Industrial Conference Board; variable 9, OBE–Dodge Corporation.

[a] All regressions are based on series of 52 quarterly observations, except the one involving OC_{t-1} (variable 9) which uses 51 observations.

[b] Unadjusted (r^2); these correlations are too low to give meaningful adjusted coefficients ($\bar{r}^2$).

Table 10-6
Regressions for Investment Orders and Contracts, Quarterly Data, 1949–61

Regression No.	Constant Term	Regression Coefficients[a]									R	$\bar{R}^2$	Stand. Error[b]
		FS_{t-2}	R_t	R_{t-1}	CF_t	CF_{t-1}	CP_t	CP_{t-1}	$(U/S)_t$	$(U/S)_{t-1}$			
A1	−10.935	.025		.462				.060[c]			.919	.834	1.323
	(3.317)	(.003)		(.074)				(.039)					
A2	−8.988	.024		.568						.416	.925	.847	1.272
	(1.625)	(.002)		(.063)						(.163)			
A3	−8.460	−.010[c,d]				.416		.101			.917	.831	1.339
	(3.496)	(.008)				(.068)		(.037)					
A4	−2.475	−.028[c]				.592				.063	.925	.847	1.271
	(1.253)	(.007)				(.065)				(.017)			
A5	−17.746	.028	.376				.146				.944	.884	1.107
	(2.863)	(.003)	(.061)				(.034)						
A6	−11.473	.024	.603						.778		.956	.909	0.981
	(1.270)	(.002)	(.047)						(.127)				
A7	−15.206	.002[d]			.320		.172				.941	.879	1.135
	(3.112)	(.006)			(.055)		(.033)						
A8	−4.389	−.024[c]			.569				.091		.952	.900	1.031
	(1.051)	(.005)			(.048)				(.014)				

		FS_t	FS_{t-2}	R_t	CF_t	CF_{t-1}	ΔFS_t	ΔR_t	App_t	OC_{t-1}			
B1	1.007		.0025 [d]							.870	.940	.879	1.085
	(0.779)		(.0032)							(.079)			
B2	1.138		−.014 [c]			.227				.631	.954	.904	0.968
	(n.a.)		(.005)			(.062)				(.096)			
B3	−2.890		.006	.296						.605	.970	.937	0.783
	(0.807)		(.002)	(.044)						(.069)			
B4	0.924		−.017 [c]		.252					.656	.968	.933	0.810
	(0.582)		(.004)		(.040)					(.068)			
B5	0.733	.005 [d]								.823	.942	.882	1.072
	(0.784)	(.003)								(.085)			
B6	1.317						.103			.877	.954	.907	0.953
	(0.573)						(.027)			(.043)			
B7	0.675							.198		.960	.965	.928	0.840
	(0.522)							(.060)		(.038)			
B8	0.508								.524	.905	.953	.905	0.758
	(0.784)								(.250)	(.061)			

n.a. = not available.

[a] See Table 10-5 for explanation of symbols. Subscripts identify the lead of i quarters with which the given series is taken relative to the dependent variable OC_t. Standard errors are given in parentheses below the coefficients.

[b] Standard error of estimate is adjusted for degrees of freedom; in billions of dollars.

[c] Sign is "wrong," i.e., contrary to expectation.

[d] Not significant at the 5 per cent level. Coefficient is less than 1.7 times its standard error. (One-sided t test is applied because the signs expected of the regression coefficients are stated beforehand.)

When the lagged value of investment orders is included as an independent variable, still higher $\bar{R}^2$ coefficients and lower standard errors of estimate are generally obtained (Table 10-6, regressions B1–B8). FS (with or without lag) is redundant when coupled with OC_{t-1} alone, and its lagged effects are small and negative in equations that include CF. However, in combination with profits, FS again has a small but positive and significant coefficient. The inclusion of OC_{t-1} reduces but does not eliminate the significance of the other variables: $CF, R, \Delta FS$, ΔR, and App.

The one inference we are prepared to draw from these results is that apparently rather close associations exist between the estimates of new investment commitments (OC) and several factors that may be considered as potentially important determinants of investment decisions. This is worth knowing despite the obvious limitations of the statement. The calculations admittedly raise many questions and answer few. Again, improvements are sought mainly through different specifications, adjustments for price level changes, and assumptions about the lags involved.

Estimates for Constant-Dollar Data

Table 10-7 presents regressions of deflated investment commitments (OC^*) on several deflated variables and on the interest rate. To reduce the risk of bias due to joint dependencies, only those predictive equations are included in which the exogenous variables lead OC_t^* by intervals of one quarter. The explanatory factors can be placed in three groups:

1. Deflated final sales and capital stock, FS^* and K^*: The "flexible accelerator" hypothesis suggests that net investment depends positively on the former and negatively on the latter.[19] However, investment designed to replace and maintain the capital stock should be positively related to the size of that stock. Since OC^* reflects gross

[19] FS^* performs here the role of output (X) in the basic formulation of this hypothesis by R. M. Goodwin ("The Nonlinear Accelerator and the Persistence of Business Cycles," *Econometrica*, January 1951, pp. 1–17) and Hollis Chenery ("Overcapacity and the Acceleration Principle," *ibid.*, January 1952, pp. 1–28). A simple version of this model is given by the equation $I_t = b(\beta X_t - K_{t-1})$, where β is the desired capital-output ratio and b is the "reaction coefficient," or fraction of the difference between the desired and the available capital stock that is acquired during the current period. This model implies that X_t is equated to the expected output and that no excess capacity is carried or wanted by business firms.

rather than net investment commitments (that is, it includes orders and contracts for reinvestment as well as new investment), the sign of the coefficient of K^* might seem uncertain. But recent studies by Jorgenson and associates indicate that replacement investment per quarter represents on the average a small proportion of the capital stock, about 0.025 or 0.03.[20] My estimates of the coefficient of K^*_{t-1} in equations for OC^*_t fall mainly in the range from −0.45 to −0.48.[21] This coefficient may be viewed as the sum $(\mu + \delta)$, where μ denotes the marginal effect of capital stock on *net* investment commitments. If $(\mu + \delta) = -0.48$ and $\delta = 0.03$, $\mu = -0.51$. The negative component definitely outweighs the positive one in these estimates, which seems entirely plausible.[22]

The "capital requirements" series (CR^*) represents a synthetic variable to be used in alternative tests of the accelerator hypothesis. Similarly, the change in final sales (ΔFS^*), when included as a single lagged term, may be viewed as representing yet another version (the early and rigid one) of the acceleration principle. This version has well-known implications for the dynamics of growth and cycles (owing mainly to the 1939 work by Paul A. Samuelson), but it is now widely recognized as a rather crude concept and decidedly inferior to the more recent flexible- and distributed-lag accelerator models.

2. Deflated corporate cash flow (CF^*) stands for the "financial" influences, and deflated profits (R^*) share partly in this role, but may also reflect the effects of changing cost-price relations and expectations. First differences in these variables are used partly to examine somewhat more complex lag patterns and partly to capture the possible expectational contents of these terms; also, as noted earlier, changes in profits may act as a proxy for profits diffusion.

3. The interest rate (i) measures, no doubt quite imperfectly, the costs of capital. It is included in each equation. Its effect on investment demand is expected to be negative, of course.

[20] See Dale W. Jorgenson and James A. Stephenson, "Investment Behavior in U.S. Manufacturing, 1947–1960," *Econometrica*, April 1967, pp. 178–79, 192, 211–12.

[21] These are the estimates from the regressions that use "causal" variables only—that do not include the term OC^*_{t-1}. When the latter is included, the coefficient of K^*_{t-1}, while still negative, is sharply reduced and appears not to be significant; see text below for some thoughts on this result.

[22] In the words of Carl F. Christ, ". . . if firms desire to make up in one year more than about 4 per cent of the difference between desired and actual capital, as seems highly reasonable, the coefficient [of K^*_{t-1}] can be expected to be negative in a gross investment equation, but it is not expected to exceed or even to equal 1 in absolute value" (*Econometric Models and Methods*, New York, 1966, p. 583). Christ assumes that δ is about .04.

Table 10-7

Regressions for Investment Orders and Contracts in Constant Dollars, One-Quarter Lags, 1949–62

Regression No.	Constant Term (1)	Regression Coefficients[a] FS^* (2)	K^* (3)	CR^* (4)	ΔFS^* (5)	R^* (6)	ΔR^* (7)	CF^* (8)	i (9)	OC^* (10)	Adj. Coeff. of Det. ($\bar{R}^2$) (11)	Stand. Error of Est. (bill. dol.) (12)	Durbin-Watson Statistic[b] (13)
C1	−20.704	.227	−0.484			1.200			−3.530		.742	3.429	1.002
	(7.560)	(.039)	(0.212)			(0.170)			(1.686)				
C2	−14.122	.086	−0.078[c]			0.695			−2.272[c]	.523	.825	2.826	1.782
	(6.369)	(.043)	(0.193)			(0.173)			(1.412)	(.105)			
C3	17.246	.312	−1.028				.398[c]		−3.858[c]		.500	4.770	0.514
	(n.a.)	(.051)	(0.276)				(.324)		(2.374)				
C4	4.357	.032[c]	−0.063[c]				.656		−1.058[c]	.812	.808	2.957	2.196
	(n.a.)	(.044)	(0.202)				(.203)		(1.504)	(.090)			
C5	−7.908			.069				1.198	−1.526[c]		.650	3.994	0.699
	(4.705)			(.035)				(0.200)	(1.205)				

C6	−4.246 [c]			−.046 [c,d]				0.688	−2.525	.710	.830	2.786	1.956
	(3.318)			(.029)				(0.156)	(0.651)	(.096)			
C7	−8.025				.223			1.343	−2.335		.643	4.030	0.698
	(4.752)				(.131)			(0.170)	(1.074)				
C8	−3.470 [c]				.127 [c]			0.605	−1.635	.612	.828	2.803	1.865
	(3.360)				(.092)			(0.154)	(0.752)	(.082)			
C9	−31.856	.308	−0.483	−.044 [c,d]		1.843		−0.620 [c,d]	−5.289		.741	3.435	1.088
	(15.543)	(.073)	(0.315)	(.040)		(0.683)		(0.744)	(2.216)				
C10	−24.391	.209	−0.357		.131 [c,e]	1.237	−.308 [c,e]		−3.900		.740	3.441	0.999
	(8.208)	(.042)	(0.236)		(.131)	(0.183)	(.272)		(1.720)				
C11	5.513				.042 [c]		.661		0.016 [c,d]	.854	.810	2.945	2.268
	(2.514)				(.106)		(.217)		(0.632)	(.067)			
C12	−22.975	.225	−0.452			1.253	−.205 [c,e]		−3.745		.740	3.440	0.962
	(n.a.)	(.039)	(0.216)			(0.183)	(.250)		(1.712)				
C13	−9.464	.068 [c]	−0.068 [c]			0.535	.332 [c]		−1.737 [c]	.601	.829	2.794	2.074
	(n.a.)	(.044)	(0.191)			(0.204)	(.228)		(1.445)	(.117)			

n.a. = not available.

[a] See text for explanation of the symbols. Each of the variables identified in columns 2–10 is taken with a lead of one quarter relative to the dependent variable OC_t^*. Standard errors of the coefficients are given underneath in parentheses.

[b] On the meaning and limitations of the Durbin-Watson statistic, see text, above.

[c] Not significant at the 5 per cent level according to the one-sided t test.

[d] Sign is "wrong," i.e., contrary to expectations.

[e] On the signs of the coefficients in these cases, see text, note 25.

On the whole, the signs of estimated regression coefficients seem rather sensible. All equations with final sales and capital stock are consistent with expectations based on the capacity-accelerator hypothesis in that FS^*_{t-1} appears with positive and K^*_{t-1} with negative coefficients. However, the addition of the autoregressive factor OC^*_{t-1} reduces strongly or eliminates the significance of these variables, particularly of K^*. To see what this may mean, let us recall that the coefficient of K^*_{t-1} can be viewed as a "reaction coefficient" that is positively related to the rate of speed of these adjustments.[23] But then, if a geometric lag distribution is assumed, the coefficient of OC^*_{t-1} measures inversely the speed of adjustment of new investment commitments to changes in the causal variables. There is an ambiguity here and probably a partial redundancy, with OC^*_{t-1} proving the strongest proxy variable.

The distributed lags involved may be attributable in large part to the continuity aspects of the investment process. If drastic changes in OC^* are seen as associated with large cost, the immediately past rate of real investment commitments would, as a visible result, exercise a substantial influence upon the current rate. The lagged adjustments may then depend more on the gap between the desired and the previously achieved rates of investment commitments and realizations than on the gap between the desired and the initially available capital stock. In this situation, the "capacity accelerator" variables could still be conceived as codetermining investment along with the autoregressive factor, although their role would have to be redefined.[24] In my estimates, however, this possibility is not realized, since the effects of OC^*_{t-1} typically overwhelm those of FS^*_{t-1} and K^*_{t-1}, perhaps because of strong interactions between those variables and the resulting multicollinearity. Just to mention one source of such difficulties, the initial conditions of investment decisions, as embodied in such predetermined

[23] Assume, with L. M. Koyck, that $K_t = \alpha\Sigma_{i=0}^{\infty} \lambda^i X_{t-i}$, where $0 \leq \lambda < 1$ (*Distributed Lags and Investment Analysis*, Amsterdam, 1954, p. 22). This can be written as $K_t = \alpha X_t + \lambda K_{t-1}$ and $I_t = \Delta K_t = \alpha X_t - (1 - \lambda)K_{t-1}$. The latter form is equivalent to the equation given above in note 19, where $b\beta = \alpha$ and $b = 1 - \lambda$.

[24] Meyer and Glauber have derived the model $I_t = \alpha bS_t - bK_{t-1} + (1 - b)I_{t-1}$ from two simple assumptions: (1) that the desired capital is proportional to sales; and (2) that the delay in adjustment is proportional to the gap between the desired rate of investment and the last actual rate. If b is the reaction coefficient and the superscript d denotes the "desired" quantities, one can write (1) $K_t^d = \alpha S_t$; $I_t^d = \alpha S_t - K_{t-1}$, and (2) $\Delta I_t = b(I_t^d - I_{t-1}) = b(\alpha S_t - K_{t-1} - I_{t-1})$; from which the above formula follows directly. See J. R. Meyer and R. R. Glauber, *Investment Decisions, Economic Forecasting, and Public Policy*, Boston, 1964, pp. 26–27.

quantities as OC^*_{t-1} and K^*_{t-1}, could well be important both in their own right and as codeterminants of the relevant expectations.

In equations C5 and C6, the synthetic capital requirements variable CR^*_{t-1} is used to represent the "accelerator principle," as is ΔFS^*_{t-1} in C7 and C8. These variables, too, have the expected positive effects when OC^*_{t-1} is not included and lose significance when it is. However, when CR^* is included along with the combination of FS^* and K^*, its coefficients are either not significant or are, contrary to expectations, negative (see equation C9). Since these factors presumably represent the same or similar forces, one of them ought to be redundant, and it turns out to be CR^*. Similar tests for ΔFS^* show that the coefficients of this variable retain positive signs in equations with FS^* and K^* but that they have little or no significance.

Gratifyingly, the coefficients of the interest rate factor show the expected negative signs (Table 10-7, column 9), but their statistical significance is in some cases rather low.

Treated singly as alternatives, the profit or cash-flow variables, R^*_{t-1}, ΔR^*_{t-1}, and CF^*_{t-1}, show considerable strength, i.e., the coefficients are positive and tend to be large relative to their standard errors. However, the cash flow variable is not significant when it is included along with profits (see equation C9). Also, ΔR^* turns out to have negative and very weak effects (if any) when used jointly with P^* (see regressions C10, C11, and C12).[25]

While the effects of the accelerator variables (Table 10-7, columns 2–5) are strongly reduced by the inclusion of OC^*_{t-1}, those of the profit variables (columns 6–8) are affected much less. It is possible that this reflects a basic difference between the two sets of influences: The pressures of demand upon capacity work more as a longer-term factor in shaping the trends of capital commitments and outlays, while the profit variables are primarily effective as determinants of short-term-investment timing decisions.

In particular, it is interesting to observe that in equation C3, which does not contain the autoregressive term OC_{t-1}, both FS^*_{t-1} and K^*_{t-1}

[25] Note that, if R^*_{t-1} has a positive coefficient (e.g., 1.2), then an absolutely smaller but significant *negative* coefficient of $\Delta R^*_{t-1} = R^*_{t-1} - R^*_{t-2}$ (e.g., −0.3) would imply positive coefficients for both R^*_{t-1} and R^*_{t-2} (of 0.9 and 0.3). Hence a negative sign associated with the change term need not in such cases be "wrong" or inconsistent with expectations. By the same token, if ΔR^*_{t-1} makes no significant contribution in addition to that of R^*_{t-1}, neither should R^*_{t-2}. In practice, to be sure, it is difficult to rely on such arguments because collinearities are often involved. *Mutatis mutandis*, the same applies also to the combination of FS^* and ΔFS^*.

show significant coefficients, while the effect of R^*_{t-1} is quite weak. When OC^*_{t-1} is added to these variables, in equation C4, the situation is reversed. Thus, the flexible-accelerator combination of final demand and capital stock appears to be "explaining" much the same component of OC^*_t as is determined by the previous values of that variable, only less effectively. This autoregressive component probably consists largely of the more persistent movements of OC^*, notably its growth. The deviations of OC^* from its trend thus defined might then be largely due to *changes* in such factors as sales and profits, which are believed to influence investment.

Some further tests were made to examine this hypothesis. They give it a modest degree of support inasmuch as they confirm that profit changes in the preceding quarter tend to have a measurable influence upon new investment commitments in equations that incorporate lagged values of OC^*, such as C11 in Table 10-7. At the same time, it is clear that ΔFS^*_{t-1}, when used jointly with ΔR^*_{t-1}, fails to exhibit such an influence. However, one must recognize that equations such as C11 are not satisfactory—in my view mainly because of the omission of the consistently significant profits variable R^*_{t-1}. The failure of the interest variable i_{t-1} to be effective in such models is also related to this omission.

The equations that do not contain the autoregressive factor OC^*_{t-1} account for up to 74 per cent of the variance of new investment commitments (column 11). The highest $\bar{R}^2$ in this category is produced by regression C1, which includes four causal variables (FS^*, K^*, R^*, and i), each of which is apparently significant. The addition of ΔFS^* and ΔR^* to this equation does not improve results, as shown by regressions C10 and C12. When OC^*_{t-1} is added, the proportion of variance "explained" rises to more than 80 per cent. These are fairly satisfactory results considering the limitations of the measurements used.[26] However, the Durbin-Watson statistics (column 13) are low for the equations without OC^*_{t-1}, suggesting the presence of substantial positive autocorrelations in the residuals.

The estimate OC^*_{est} from equation C1 is compared with the actual values of new investment orders and contracts, OC^*, in Chart 10-3.

[26] The correlations are in general lower here than for the current-dollar series in Table 9-6, which need not be surprising because the deflation procedure eliminates some of the common trends in the series included and may also introduce some additional measurement errors.

The fit leaves much to be desired in the first five years covered, when OC_{est} greatly underestimated first the rise of OC^* in 1949–51 and then the decline of OC^* in 1951–54. The two series move appreciably closer to each other in the later years, but the movements of OC^*_{est} exceed those of OC^* on the downgrade in 1957–58 and on the upgrade in 1961–62. The deviations of OC^*_{est} from OC^*, that is, the residuals from the regression C1, are shown as the bottom curve in panel B of Chart 10-3. They clearly retain elements of positive autocorrelation and are also similar to some of the systematic movements in investment commitments. The latter relationship is evident primarily in 1949–54; in later years, it is rather blurred, and at times negative. Over the period as a whole, a positive correlation between the residuals u_t and the lagged commitments OC^*_{t-1} is indicated. When OC^*_{t-1} is used jointly with the causal variables included in Chart 10-3 the new residuals have a substantially smaller variance and autocorrelation than the residuals shown in the chart (compare equations C1 and C2 in Table 10-7). It appears that new investment commitments are difficult to predict, particularly without the autoregressive factor, presumably because they move early and depend in large part on "autonomous" expectations for which we have no good proxy measures.

No systematic timing differences are observed in panel A of Chart 10-3: OC^*_{est} led OC^* in 1951 and 1960, lagged behind OC^* in 1956 and 1961, and turned upward coincidently with OC^* in 1954 and 1958. Such leads or lags as occurred at these turning points were typically short (one quarter), and the average timing is nearly coincident. Panel B of Chart 10-3 shows that the early turns in OC^*_{est} are attributable to two of its components: $1.200R^*_{t-1}$ and $-3.530i_{t-1}$. These elements of equation C1 had early peaks and troughs in most of the turning-point zones covered. Neither FS^*, which moved late, nor K^* which had almost no turns, could have contributed to the relative accuracy of timing of these estimates.[27]

Importantly, then, these findings indicate that the pervasive leads of new investment commitments in business cycles have been closely associated with the fluctuations in profits, and, to a somewhat narrower

[27] Graphs analogous to those in Chart 10-3 were prepared for estimates from equation C12, which includes, in addition to the factors used in C1, the change in profits, ΔR^*_{t-1}. The latter tends to have early turns, which makes it a potential contributor to the timing of new investment commitments, but its effectiveness in C12 seems close to nil. The curve of OC^*_{est} from C12 is a virtual replica of the estimated series shown in Chart 10-3, panel A.

extent, with interest rates. These two variables can "explain" a large proportion of the cyclical movements in new orders and contracts, whereas the others are almost entirely ineffective in this respect.

Varying the Assumed Timing Relations

When the lags of OC_t^* relative to the explanatory variables are increased, the fits definitely deteriorate (Table 10-8). The $\bar{R}^2$ coefficients reach into the .75 to .85 range for the one-quarter lags; they are con-

Chart 10-3
Regressions of New Investment Orders and Contracts in Constant Dollars on Final Sales, Capital Stock, Corporate Profits, and Interest Rates, Quarterly, 1949–62

$$\hat{OC}_t^* = -20.7 + .227FS_{t-1}^* - .484K_{t-1}^* + 1.200R_{t-1}^* - 3.530i_{t-1}$$

A. ACTUAL AND ESTIMATED VALUES OF OC_t^*

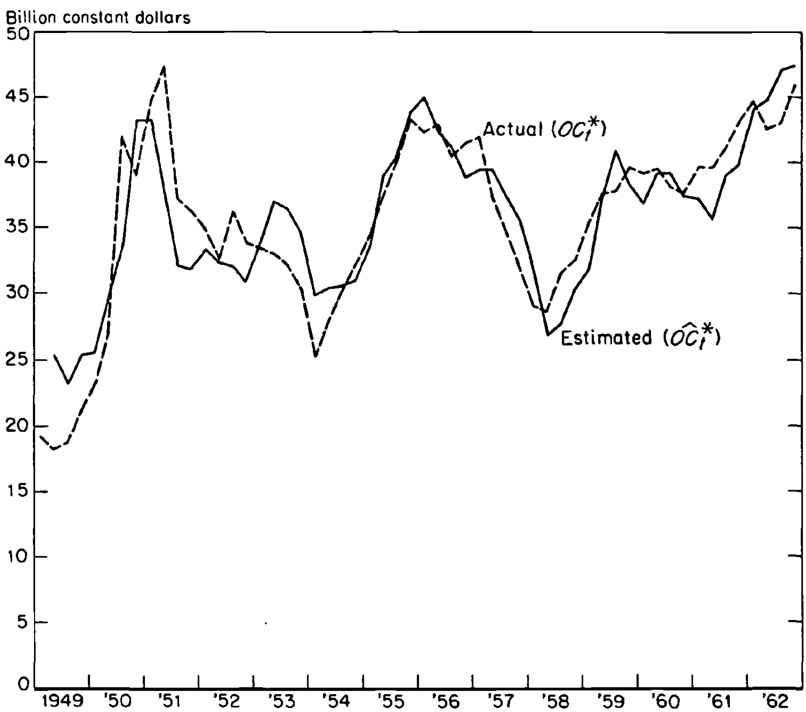
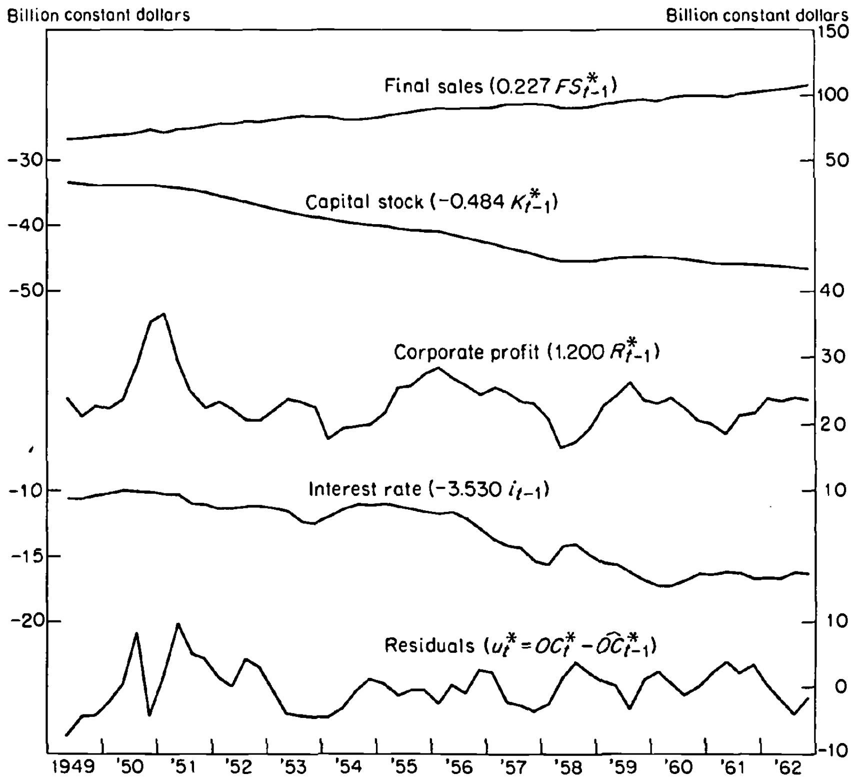


Chart 10-3 (concluded)

B. COMPONENTS OF THE ESTIMATED VALUES AND RESIDUALS



centrated in the .55 to .75 interval for the two-quarter lags, and in the .35 to .55 interval for the three-quarter lags (column 11).[28]

On the whole, the profit variables are rather successful in retaining their significance as the lags are lengthened, whereas the accelerator variables are not (compare the corresponding estimates for the regression sets C, D, and E in columns 2–5 and 6–8 of Tables 10-7 and 10-8). This result suggests that, on the average, the lags of OC^* may be larger

[28] This statement and the following ones are based on more evidence than is presented in Table 10-8. The table omits some regressions, such as E3 and E5 (corresponding to E4 and E6 but without the term OC^*_{t-3}), that add little to the picture provided by our estimates.

Table 10-8
Regressions for Investment Orders and Contracts in Constant Dollars, Two- and Three-Quarter Lags, 1949–62

Regression No.	Constant Term (1)	Regression Coefficients[a] FS^* (2)	K^* (3)	CR^* (4)	ΔFS^* (5)	R^* (6)	ΔR^* (7)	CF^* (8)	i (9)	OC^* (10)	Adj. Coeff. of Det. ($\bar{R}^2$) (11)	Stand. Error of Est. (bill. dol.) (12)	Durbin-Watson Statistic[b] (13)
					WITH LEADS OF TWO QUARTERS RELATIVE TO OC_t^*								
D1	−19.035	.170	−.198[c]			1.117			−4.054		.589	4.076	0.822
	(8.990)	(.048)	(.258)			(0.203)			(2.006)				
D2	−15.628	.094[c]	.028[c]			0.864			−3.384[c]	.264	.605	3.995	0.820
	(9.026)	(.065)	(.284)			(0.246)			(2.004)	(.152)			
D3	18.124	.244	−.734				0.948		−3.652[c]		.431	4.793	0.668
	(7.762)	(.054)	(.284)				(0.326)		(2.389)				
D4	8.118[c]	.002[c]	.106[c]				1.169		−1.267[c]	.660	.652	3.749	1.278
	(6.323)	(.060)	(.267)				(0.258)		(1.915)	(.116)			
D5	20.022			.106			1.075		3.042[d]		.288	5.364	0.613
	(4.559)			(.038)			(0.360)		(1.061)				
D6	13.741			−.113[d]			1.305		−1.255[c]	.919	.716	3.390	1.720
	(2.970)			(.035)			(0.229)		(0.832)	(.105)			

D7	−3.244 [c]				.121 [c]			1.266	−2.602		.551	4.258	0.830
	(5.152)				(.133)			(0.183)	(1.134)				
D8	−0.529				.067 [c]			0.840	−2.202	.351	.615	3.947	0.907
	(4.860)				(.130)			(0.220)	(1.060)	(.116)			
WITH LEADS OF THREE QUARTERS RELATIVE TO OC_i^*													
E1	−7.605 [c]	.110	.009 [c]			0.770			−3.652 [c]		.310	4.933	0.540
	(10.891)	(.061)	(.320)			(0.245)			(2.432)				
E2	−6.749 [c]	.090 [c]	.069 [c]			0.709			−3.482 [c]	.063 [c]	.297	4.980	0.523
	(11.304)	(.087)	(.372)			(0.309)			(2.551)	(.195)			
E4	13.541	−.010 [c,d]	.196 [c]				1.300		−1.154 [c]	.424	.433	4.472	0.815
	(7.543)	(.077)	(.334)				(0.308)		(2.294)	(.142)			
E6	4.862 [c]			−.202 [d]				1.112	−4.846	.463	.566	3.911	0.577
	(4.926)			(.041)				(0.224)	(1.195)	(.140)			
E7	5.915 [c]				.210 [c]			0.936	−1.609 [c]		.373	4.702	0.575
	(5.836)				(.153)			(0.204)	(1.253)				
E8	6.571 [c]				.197 [c]			0.839	−1.520 [c]	.079 [c]	.364	4.735	0.555
	(5.988)				(.156)			(0.267)	(1.272)	(.139)			

[a] See text for explanation of symbols. Standard errors of the coefficients are given underneath in parentheses.

[b] On the meaning and limitations of the Durbin-Watson statistic, see text, above.

[c] Not significant at the 5 per cent level according to the one-sided t test.

[d] Sign is "wrong," i.e., contrary to expectations.

relative to the profit than relative to the accelerator variables.[29] It is not necessarily disturbing for the concept of the longer-term distributed-lag accelerator (although it might seem so at first sight), since that concept is not in any sense adequately tested here; the comparisons concern mainly the applications of different discrete lags.

The coefficients of the interest rate variable (i) appear to be fairly stable in the transition to larger lags: they neither increase nor decrease markedly relative to their standard errors (column 9). Their signs, too, remain in most cases appropriately negative, but their statistical significance is quite low, with few exceptions.

As would be expected, the importance of the autoregressive terms OC^*_{t-j} is reduced substantially as j is increased from one to two quarters and reduced still more for $j = 3$ quarters (Tables 10-7 and 10-8, columns 10). In fact, OC^*_{t-3} is not significant in some cases, e.g., regressions E2 and E8.

Different explanatory variables need not, of course, have the same timing relative to OC^*_t. Another set of equations (group F) was therefore estimated, using for each variable the lead that maximizes its simple correlation with OC^*_t. But there was no improvement over the results reported in Table 10-7. The scope for improvement was limited in the first place, since the correlation-maximizing leads turned out in general to be one-quarter leads.[30]

Additional calculations were made to examine the possibility that second-order lag models are applicable to the determination of new investment commitments. Their verdict was negative: when OC^*_{t-2} was added to the regressions, its coefficients consistently turned out to have very little or no statistical significance.

The Implicit Lag Structure

One can think of two reasons why investment commitments should follow the determinants of investment decisions with gradual distributed lags rather than with short discrete lags. First, the recognition of

[29] Using very different data—annual cross sections and time series for 1935–55—Edwin Kuh reports that "the strongest influence on investment [expenditures] came from lagged (or the average of lag and present) profit and not from current profit, while the influence of capacity pressure appears strongest in the current rather than in the preceding year." This result, then, is qualitatively similar to ours. See Kuh, *Capital Stock Growth: A Micro-Econometric Approach*, Amsterdam, 1963, Chap. 8 and p. 333.

[30] For K^* and ΔR^* simple correlations suggested four-quarter leads, but in the multiple regressions one-quarter leads often proved to be appropriate for these variables, too.

the need for additional productive facilities and the decision to acquire them may be based on a string of past values, rather than on a single value, of certain indicators. Second, even if the decision to invest relates to a whole project, the placement of orders for the project may be spaced over time. The first reason is plausible in that the recognition of the gap between the desired and the actual capital stock probably does require more than a single determinant value, but it is not at all clear that the decision to invest must depend on a *long* sequence of indications. The second reason is independent of the first inasmuch as it suggests some form of a distributed lag even if the need for the investment was recognized with little delay; but the lags involved here could very well be relatively short and clustered. Once the shortage of the available capital stock is perceived, ordering may be expected to follow promptly to implement the investment decision with least delay.

It seems implausible in light of these considerations that the determination of investment commitments should be a process of such slow lagged adjustments as are implied by several regressions in Table 10-6, Group B. These are the equations that show very high coefficients of the lagged dependent variable (OC_{t-1}), e.g., B6, which is a very rudimentary version of a distributed-lag accelerator, where the average lag would be about seven quarters; or B7, which is an analogous model with profits, where the reaction is still more protracted. In such cases, the implied lag pattern indicates little more than the apparent inadequacy of the specifications used.

In contrast, B3 yields the highest correlation in this set, suggesting a much more concentrated lag pattern, with half of the effect on OC_t of a maintained change in the causal factors (as of the time t) requiring no more than 1.4 quarters to work itself out. Two other regressions in this group, B2 and B4, imply similar lagged distributions averaging 1.7 and 1.9 quarters.

It is clear that the estimates of the structure of the lag differ drastically depending on which variables are assumed to have influenced the placing of investment orders through time. They are highly sensitive to b, the value of the coefficient of OC_{t-1}. When relevant causal variables are omitted, or when the included causal variables are weak or irrelevant, that coefficient is very high, giving rise to estimates of apparently unduly long lags.

It is likely that some factors influence investment decisions more gradually and others relatively promptly. In principle, if such influences occur jointly, the net contribution of each ought to be evaluated simultaneously, but in practice it is very difficult to estimate the partial distributed-lag effects of each of the different codeterminants even if there are only a few. The reason is high multicollinearity, as noted in Chapter 7.

The constant-dollar equations in Table 10-7 produce a much narrower range of lags whose duration is relatively short. Regressions C2, C6, and C8 give the best fits with few variables and reasonable estimates for their coefficients. The average lags computed according to the formula $b/(1 - b)$ are here 1.1, 2.4, and 1.6 quarters, respectively, but since the independent variables are for $t - 1$, 1.0 must be added to each of these three figures. With this adjustment, the equations imply that for $q = 0.5$ (that is, to account for 50 per cent of the total long-run reaction involved), the necessary lags n vary from 2.1 to 3.0 quarters; for $q = 0.7$, the range of n is from 2.9 to 4.5 quarters; and for $q = 0.9$, it is from 4.6 to 7.7 quarters.[31] The gist of this analysis is that the lags on balance are probably not very large. Half or more of the value of new investment orders and contracts are placed in the first six or nine months following a hypothetical maintained change in the factors combining to influence the investment decision. Most of the new commitments that remain are made in the next couple of quarters.

Comparisons with Other Lag Estimates

While studies of the determinants of investment expenditures abound, there are very few such studies for investment commitments. Kareken and Solow[32] describe a series of experiments with quarterly regressions in which fixed-investment demand is represented by the deflated series of nonelectrical machinery orders, N_t. They settle on equations relating N_t positively to industrial production and corporate profits and negatively to industrial bond yields. These equations are said to suggest, as a "rough statement," that "of the full long-run effect of the determining variables on new orders, about 45 per cent takes place in

[31] For the formulas linking n and q, see the discussion following equation (Z) near the end of Chapter 9.

[32] John Kareken and Robert M. Solow, "Lags in Fiscal and Monetary Policy," in Commission on Money and Credit, *Stabilization Policies*, Research Study One, Part 1, Englewood Cliffs, N.J., 1963, pp. 31–38.

the first quarter in which a change occurs, another 25 per cent in the following quarter, 14 per cent in the next quarter, 8 per cent in the next quarter, and 4 per cent in the quarter after. Thus about 90 per cent of the long-run effect would run its course in a year."[33]

The coefficients of N_{t-1} in the Kareken-Solow estimates, approximately 0.55 or 0.58, are quite close to the coefficients of OC^*_{t-1} in our equations C2 and C8, which are 0.52 and 0.61; consequently, the lag structures computed from these statistics are similar.[34] However, the causal variables in the C regressions have subscripts $t - 1$, while those in the Kareken-Solow regressions have subscripts t. Also, other related equations (notably C6 in Table 10-7, which deserves consideration) show higher coefficients of OC^*_{t-1}. On the whole, therefore, my estimates imply slower lagged reactions than those reported by Kareken and Solow. Whereas they suggest that slightly more than 90 per cent of the hypothetical "total response" of investment commitments would be completed within one year, my results indicate that this proportion is perhaps nearer three quarters (the best estimates, in my view, run from 64 to 86 per cent).

This relatively modest discrepancy has no simple explanation, since the estimates differ in more than one respect. However, one probable reason for it is that N includes only nonelectrical machinery orders, whereas my regressions refer to plant contracts as well as equipment orders, both of these categories being represented in OC^*. Some new industrial equipment is bought in conjunction with the construction of new plants or plant additions, but some is bought for installation in al-

[33] *Ibid.*, p. 38. Kareken and Solow first included an industrial capacity variable along with the FRB production index (Z), but that variable lost its statistical significance with the inclusion of net corporate profits (R), and was dropped. Among others, the following estimates were obtained (with Z = FRB index × 10 and i = bond yield × 100):

$$N_t = -2513.2 + \underset{(0.339)}{1.857}Z_t + \underset{(0.228)}{1.225}R_t - \underset{(2.543)}{4.131}i_t; \quad R^2 = .778$$

$$N_t = -1391.1 + \underset{(.294)}{.929}Z_t + \underset{(.193)}{.660}R_t - \underset{(1.902)}{2.662}i_t + \underset{(.090)}{.547}N_{t-1}; \quad R^2 = .881$$

[34] To show this similarity, let us tabulate for C2 the increments $\Delta q \times 100$ (per cent) as a function of n (quarters), which is the form used in the Kareken-Solow statement.

n	1	2	3	4	5
$\Delta q \times 100$	47.7	25.0	13.0	6.8	3.6

It should be noted that these equations are broadly comparable as far as their independent variables are concerned. The roles of FS^* in our regression and of Z in theirs are probably rather similar. Both equations include profits and interest rate variables. C2 also includes the capital stock (K), which however lacks significance.

ready existing structures. For such independent equipment purchases, the lags involved in placing (as well as in executing) new orders may well be considerably shorter than the lags that relate to industrial plant contracts and to the associated equipment orders. According to one study, only about two months elapse on the average between the realization of the need for a piece of equipment and the date of the purchase order.[35]

In recent work by Hart,[36] deflated capital appropriations by large manufacturing corporations (quarterly NICB data) are related to an index of the ratio of new orders to productive capacity for all manufacturing (called *ORCA*) interpreted as an expectational variable corresponding to the accelerator hypothesis. When App_t is thus regressed on three terms $(ORCA)_{t-i}$, $i = 0, 1, 2$ quarters, an $\bar{R}^2$ of .847 results, indicating a better fit than that obtained from an autoregressive equation linking App_t to App_{t-1} and App_{t-2} (where $\bar{R}^2 = .747$). Starting from a regression of App_t on the three *ORCA* terms and the lagged interest rate, Hart then adds the autoregressive factors App_{t-1} and App_{t-2} and finds that their contribution is trifling. Indeed, the estimate of the average of the implied lag distribution would seem unacceptable to one who believed that *App* systematically lags *ORCA*.[37]

There is, however, reason to doubt that such lags should in fact exist. I have suggested elsewhere that the role of *ORCA* can be explained without reference to the accelerator theory.[38] Changes in that variable reflect mainly the movements in new orders for durable goods which are highly correlated with new investment orders and contracts. Hence,

[35] This result comes from a study, by the National Industrial Advertisers Association, of equipment purchases in manufacturing plants with over 500 employees. It is quoted in Thomas Mayer, "The Inflexibility of Monetary Policy," *Review of Economics and Statistics*, November 1958, p. 364. A similar estimate of the lag by George Terborgh is also cited. Note however that the date of the "realization of the need" appears to be approximated by the date of authorization for the expenditure, and the latter can have a substantial lag behind the timing of changes in the "causal factors" here considered.

[36] Albert G. Hart, "Capital Appropriations and the Accelerator," *Review of Economics and Statistics*, May 1965, pp. 123–36.

[37] The regression coefficients of App_{t-1} and App_{t-2}, with their standard errors in parentheses, are 0.3149 (0.1758) and −0.2314 (0.1310), respectively (*ibid.*, p. 131; I have changed the symbols to correspond to the notation used earlier in this book). Applying the formula $\bar{n} = (b + 2c)/(1 - b - c)$ to these estimates of b and c results in a small *negative* fraction, −0.161. It is true that the applicability of the formula may be questioned because of dimensionality problems. But note also that the regression coefficients of the lagged *ORCA* terms in Hart's equation are not large relative to their standard errors, whereas the coefficient of the simultaneous term is large and definitely significant.

[38] Victor Zarnowitz, Comment on Reynold Sachs and Albert G. Hart, "Anticipations and Investment Behavior: An Econometric Study of Quarterly Time Series for Large Firms in Durable Goods Manufacturing" in *Determinants of Investment Behavior*, Universities–National Bureau Conference 18, New York, NBER, 1967, pp. 596–99.

ORCA is likely to derive most of its influence from being actually another form of an anticipatory variable, like investment commitments, and similar to as well as, probably, roughly coincident with, capital appropriations.

Integrating the Results on Commitments and Expenditures

Average Lead Times for Business Investment in Plant and Equipment

Estimates presented in the preceding part of this chapter suggest that new investment orders and contracts lag an average of two to three quarters behind the variables that are presumed to influence investment decisions. Most of the new commitments are probably made within the first year after the motivating change in the investment determinants, although some will no doubt be made later, over a considerable stretch of time. In general, these lags are likely to be quite differentiated and variable, and they seem difficult to define, let alone to evaluate, in any rigorous manner.

The lags of investment realizations behind new investment commitments can be much better defined and measured. Not surprisingly they tend to be quite substantial. Investment in plant and equipment involves new construction and acquisition of capital goods that must be produced according to the specifications of the investor and prospective user. This process, starting from the new appropriations made or orders placed and ending at the stages of output or expenditures, is ordinarily time-consuming. The lags are gradual, i.e., distributed, but some minimum delay is likely to occur before the new commitment will begin affecting expenditures. The lag distribution may be unimodal, that is, it may incorporate an initial build-up effect of orders. It is probably often skewed as that effect tails off slowly. According to the various estimates reviewed in the last part of Chapter 9, the average lags of business fixed-investment outlays relative to commitments range from three to about five quarters. In the first year after the orders for capital goods had been placed, perhaps only 50 percent of their full long-run effect on spending will have been completed.

A rough estimate of the time required for plant and equipment expenditures to register major changes in response to factors influencing investment decisions is obtained by adding the two average lags, thus accounting for both the time needed to reach the decision and the time needed to implement it. My estimates for the combined average lag vary approximately between five and eight quarters.

According to the estimates by Kareken and Solow, four to five quarters are required to account for about half of the "full effect" of new orders on production of business equipment. The corresponding "half-life" estimate for the impact of selected determining variables on new orders is one quarter or a little more. These figures add up to an average lag of five to six quarters for the relation between the determining factors and equipment output. This is within the lower part of the range of my estimates.

Frank de Leeuw, in relating plant and equipment expenditures by manufacturers to "capital requirements," internal funds (cash flow), and bond yields, tried Koyck, rectangular, and inverted V (symmetrical triangular) lag distributions.[39] The last approach gave the best result of the three when weights were used which increased for six quarters and declined for another six. Although the lag pattern is in this case quite different, the average lag estimate (about 6.5 quarters) again resembles the others.

In the first of his papers on investment behavior, Jorgenson suggested that "the average lag between change in demand for capital stock and the corresponding net investment is, roughly, 6.5 quarters or about a year and a half."[40] In a related later study, estimated patterns of lagged response based on applications of the general Pascal lag distribution are presented for total manufacturing and several of its major subdivisions.[41] The data are quarterly, for the period 1949–60. The fitted functions imply asymmetrical patterns that typically rise steeply

[39] De Leeuw, "Demand for Capital Goods," pp. 415–19.

[40] Dale Jorgenson, "Capital Theory and Investment Behavior," *American Economic Review*, May 1963, p. 259. In this work, net investment is a distributed-lag function of one or more differences in a computed "desired capital stock" variable and replacement investment is proportional to capital stock. The desired capital stock is estimated from a formula that includes the value of output, price of capital goods, interest, and tax rates on business income. The main aims are to link the investment function to the neoclassical theory of capital, assuming net worth maximization as the objective of the firm, and to generalize the lag structure involved. Possible implications of uncertainty and entrepreneurial preference for internal financing, as well as of short-run fluctuations in the rate of utilization of the capital stock, are disregarded. In practice, the excellent fits obtained by Jorgenson are due in large measure to his use of the OBE-SEC investment anticipations data.

[41] Dale W. Jorgenson and James A. Stephenson, "The Time Structure of Investment Behavior in United States Manufacturing, 1947–1960," *Review of Economics and Statistics*, February 1967, pp. 16–27. Similar estimates for four comprehensive industrial groups are also given.

for three or four of the shortest lags and then tail off gradually in the direction of intermediate and long lags. The average lag for total manufacturing is computed to be 8.5 quarters; the corresponding estimates for the various industries vary from 6 to 11 quarters. These results are for net investment, but those for gross investment are described as quite similar during a long initial phase of about three years following the change in desired capital.

The 1964 study by Meyer and Glauber includes, in addition to an extensive analysis of cross-sectional data, an exploration of investment behavior based on quarterly time series.[42] Their focus is on testing different hypotheses about the determinants of capital outlays of business corporations; while not directly concerned with the estimation of distributed lags in the investment process, their study is instructive in the present context. Meyer and Glauber use different explanatory variables with different timing relative to the dependent variable I_t so as to optimize the over-all fits. Thus the cash flow, capacity utilization, and stock price variables are generally taken with time subscripts $t - 1$, while the interest (industrial bond) rate, which is expected to show a negative coefficient, has the subscript $t - 3$.

The autoregressive factor used most frequently in the Meyer-Glauber study is I_{t-2}. Its coefficients vary greatly depending on the choice of causal variables, a finding that parallels what was observed repeatedly in my own results. For example, the coefficient of I_{t-2} is 0.821 when only cash flow and the capacity factor are used, 0.893 when the interest rate is added, 0.651 when the level of the stock price index is added, and 0.984 when the change in the stock price index replaces the level.[43] Several criteria of accuracy of estimation and forecasting are applied to the different equations but selection of the best one proves difficult, mainly because good structural qualities and superior forecasting performance do not coincide in the same model. The highest-ranking models suggest lag distributions with averages of 5 to 7.5 quarters for the interest rate and 3 to 5.5 quarters for the other variables, allowing for the time subscripts chosen.

[42] Meyer and Glauber, *Investment Decisions*. The data came mainly from Federal Trade Commission–Securities and Exchange Commission sources and cover the period 1949–58 (in forecasting tests, 1949–61). See especially Chapter VII.

[43] *Ibid.*, Table IX-1, p. 215. The authors observe that the last of these estimates comes disturbingly close to one (the "upper limit" for a stable process) and that it "seems unrealistically large" (*ibid.*, p. 216).

At this point it is possible to conclude that the explicit estimates of the average lag of investment in plant and equipment are all substantially the same for the studies based on quarterly postwar data. The Kareken-Solow, de Leeuw, and my own estimates are all concentrated in the range of 5–7 quarters. The results of Meyer and Glauber suggest somewhat shorter mean lags and those of Jorgenson and associates suggest somewhat longer mean lags, varying roughly from 6.5 to 8.5 quarters.[44]

In a sharp contrast to these findings from regressions based on quarterly time series for periods since 1947 are the results of studies of annual data for periods including prewar years. Thus Koyck's estimates of the speed-of-adjustment coefficient λ (see note 23, above) range from 0.7 to more than 0.9 for several industries. This implies that capital stock adjusts very slowly to changes in output: The suggested average lags are often as long as seven years and may exceed ten years. Kuh notes that his time series estimates of the "reaction coefficients" (capital stock slope coefficients) have similar implications, and that a different model by Grunfeld also yields "approximately consistent" results.[45] Long lags of capital expenditures are likewise involved in Eisner's work with company data from the McGraw-Hill annual surveys, where sales changes in each of the six preceding years are used as codeterminants of the current year's outlays.[46]

The lags suggested by the studies of annual data are so long that they are difficult to rationalize. Moreover, independent evidence from surveys of new or expanding manufacturing plants suggests that it takes

[44] Zvi Griliches and Neil Wallace have used Jorgenson's and their own estimates of investment functions to illustrate "the fact that a small difference in the estimated regression coefficients can imply substantial differences in the derived form of the distributed lag" ("The Determinants of Investment Revisited," *International Economic Review*, September 1965, p. 322). Their equation in this comparison yields an implausibly long average lag. However, other estimates presented in the same paper imply lags that are much shorter and closer to the figures quoted in the text above. Thus the average lag of investment expenditures behind the rate of interest and the stock price index is 4.7 quarters, according to "one of the better fitting" equations of Griliches and Wallace (compare Zvi Griliches, "Distributed Lags: A Survey," *Econometrica*, January 1967, p. 30).

[45] Kuh, *Capital Stock Growth*, p. 293. Kuh's reaction coefficients are typically in the neighborhood of 0.08 and do not exceed 0.15 (*ibid.*, Table 9.1, p. 294; on the meaning of such coefficients and their relation to Koyck's coefficients, see notes 19 and 23, above). Grunfeld's estimates are based on annual time series for six large corporations and cover the period 1935–54; they relate gross investment to the capital stock and market value of each firm at the beginning of the year and yield capital stock coefficients ranging from 0.003 to 0.400 (Yehuda Grunfeld, "The Determinants of Corporate Investment," in A. C. Harberger, ed., *The Demand for Durable Goods*, Chicago, 1960, pp. 255–57).

[46] For the most recent reports on this project, see Robert Eisner, "Investment and the Frustrations of Econometricians," *American Economic Review*, May 1969, pp. 50–64; and Eisner, "A Permanent Income Theory for Investment: Some Empirical Explorations," *ibid.*, June 1967, pp. 363–90. For references to earlier reports, see the June 1967 article and Chapter 9, note 32, above.

on the average about seven quarters for a decision to build to result in the completion of the project.[47] The lags estimated from regressions of annual data are often five to eight *years* longer, and it is hard to see why this much time should have to elapse on the average between changes in the investment-motivating factors and the decision to invest. On the other hand, the estimates from the quarterly regressions are certainly much closer to, and seem on the whole reasonably consisaent with, the survey results. The latter are summarized by the following mean lead times (averages for all types of plants weighted by the cost of project), which were obtained by Thomas Mayer from questionnaires sent to companies that were reported by the *Engineering News Report* to be building industrial plant during 1954.

From:	*To:*	*No. of Months*	*No. of Cases*
Start of consideration	Start of construction	23	64
Start of drawing of plan	Start of construction	7	61
Placing of first significant orders	Start of construction	2	70
Start of construction	Completion of project	15	77

According to these figures, the average lead of first orders relative to the realized investment is seventeen months, just below the midpoint of the range of 5–8 quarters indicated by my regression estimates. The lead is 4–5 months longer when reckoned from the time of "drawing plans" or making the "final decision." The average interval from the "start of consideration" of a new project to the "first significant orders" is a relatively long one of about 7 quarters; it exceeds considerably the average lags suggested by my regression analysis of new investment commitments. However, the initial stage is here but vaguely denoted; e.g., if "consideration" meant just a feeling that expansion of the productive capacity in the next two years would be desirable, it might bear little relation to the timing of changes in the investment determinants. Even so, this information appears to indicate that the decision taking itself is often viewed as a rather time-consuming process in business firms engaged in expanding plant and equipment.

The possible biases in the survey results point in opposite directions,

[47] Thomas Mayer, "Plant and Equipment Lead Times," *Journal of Business of the University of Chicago*, April 1960, pp. 127–32. See also Thomas Mayer, "The Inflexibility of Monetary Policy," *Review of Economics and Statistics*, November 1958, pp. 362–64.

and their probable net impact is viewed as relatively small.[48] However, it is important to recognize that purchases of industrial equipment include not only items to be installed in new plants or plant additions but also those to be put in old buildings. The lags in decision taking are probably rather short for the latter type of equipment buying, perhaps about two months on the average.[49] To this a delivery lag, which is variable but not longer than several months, would be added, judging from our order-shipment timing comparisons and the average ratios of unfilled machinery orders to monthly sales.

To summarize the evidence, distributed lags of substantial duration prevail in the relations between investment determinants, commitments, and realizations; but the lags are better measured in quarters than in years, and they are believed to have been greatly overstated in some studies based on annual data. As implied in the discussion of this viewpoint by Jorgenson and Stephenson[50] there are several possible reasons for the discrepancy between the annual and the quarterly results, and a full explanation of the discrepancy is not yet available. The authors argue that one reason lies in the misspecification of the lag structure in studies of annual data that rely mainly on the geometric distribution; but they also believe that the discrepancy is too large to be explained only by this source of bias and that "the possibility of other errors of specification in the annual results should be explored."[51]

Investment Functions with Estimated Commitments

The procedural question from the beginning of this chapter may be reconsidered in a more concrete form. Can estimates of investment commitments derived only from previous values of causal variables provide a sufficient basis for the successful projection of investment

[48] See *ibid.*, p. 127, note 5, and p. 130; also, William W. White, "The Flexibility of Anticyclical Monetary Policy," *Review of Economics and Statistics*, May 1961, pp. 142–47; and Thomas Mayer, "Dr. White on the Inflexibility of Monetary Policy," *Review of Economics and Statistics*, May 1963, pp. 209–11.

[49] See note 35, above.

[50] "Investment Behavior," p. 26.

[51] In a recent paper, Hall and Jorgenson derive separate estimates of investment functions for equipment and for structures, using annual data for 1931–41 and 1950–63 and distributed-lag estimation methods analogous to those introduced in the earlier Jorgenson studies of investment behavior. The average lags between changes in desired capital and investment expenditures are estimated as approximately 2 years for equipment in manufacturing and 1.3 years for nonmanufacturing equipment, which agrees with the quarterly results for total business fixed investment as reported before. The corresponding averages for structures, however, are much larger: 3.8 years in manufacturing and 7.5 years in nonmanufacturing. See Robert E. Hall and Dale W. Jorgenson, "Tax Policy and Investment Behavior," *American Economic Review*, June 1967, pp. 391–414.

expenditures? An affirmative answer, if true and not due to some fortuitously favorable evidence, would suggest that: (1) the commitments data work well as a representation of the flow over time of aggregated investment decisions; (2) the determinants of the decisions can be specified in a sufficiently correct way; and (3) investment realizations, to which the expenditures are tied up, can be predicted with reasonable accuracy as some lagged function of the decisions to order capital goods. By the same token, the answer could be negative because either (1) or (2) or (3) does not hold. However, these propositions were purposely expressed in broad and cautious terms, and indeed each of them can at best be only partially valid, even if the tests come out favorably. As already noted, the available commitments data undoubtedly have serious shortcomings, and our knowledge of both the determinants of investment decisions and any possible additional factors influencing the rates and timing of expenditures is certainly quite deficient.

In the tests to follow, I shall use the estimates of new investment orders and contracts computed from regression C1 in Table 10-7. The equation is reproduced below:

$$OC_t^* = -20.704 + .227FS_{t-1}^* - .484K_{t-1}^* + 1.200R_{t-1}^* - 3.530i_{t-1}. \qquad \text{(C1)}$$

In Table 10-9, plant and equipment outlays I^* are related to the estimate of OC^* based on (C1). Geometric and second-order lag distributions are applied. The coefficients of $\hat{OC}_{t-1}^*$ are about four times as large as their standard errors in equations with I_{t-1}^* only, but just 1.3–1.5 as large as their standard errors in equations that also include I_{t-2}^* (column 2). In either set, it is redundant to include additional values of lagged commitments: the measured effects of $\hat{OC}_{t-2}^*$, where the circumflex denotes estimates derived from (C1), are negative but apparently not significant (column 3). The coefficients of I_{t-1}^* equal 0.86 and 0.88 in the geometric-lag models and rise to nearly 1.4 in the second-order lag functions, where I_{t-2}^* enters with negative coefficients, −0.48 and −0.46 (columns 4 and 5).[52]

[52] These results are at least broadly similar to those obtained in the current-dollar regressions of I_t on actual commitments OC_{t-i} and on I_{t-i} and I_{t-2} (Table 9-3). However, in Table 10-9 commitments have much lower, and lagged expenditures have higher, coefficients. This must be largely due to the change from actual to estimated commitments, but the change from current-dollar to deflated series probably also works in the same direction.

Table 10-9
Regressions for Plant and Equipment Expenditures (I) in Constant Dollars for Distributed-Lag Functions with Estimated Commitments, 1949–62

Regression No.	Constant Term (1)	Regression Coefficients[a] $\hat{OC}^*_{t-1}$ (2)	$\hat{OC}^*_{t-2}$ (3)	I^*_{t-1} (4)	I^*_{t-2} (5)	$\bar{R}^2$ (6)	SE (7)	Durbin-Watson Statistic[b] (8)
4a	−.462	.140 (.033)		0.861 (0.034)		.9640	1.016	1.168
4b	−.255	.189 (.049)	−.074[c] (.054)	0.883 (0.037)		.9646	1.008	1.324
5a	.942	.052 (.040)		1.396 (0.159)	−.483 (.141)	.9704	0.921	1.663
5b	.992	.084 (.055)	−.043[c] (.051)	1.383 (0.160)	−.460 (.144)	.9702	0.924	1.730

[a] $\hat{OC}^*$ is the estimate of new investment orders and contracts calculated from equation C1 (see the first line in Table 10-7 and text). Standard errors are given underneath in parentheses.

[b] On the meaning and limitations of the Durbin-Watson statistic, see Table 10-3, note c, and text above.

[c] Positive rather than negative sign would be expected, but the statistical significance of these estimates is very low anyway.

Chart 10-4 shows the estimates of I_t^* computed from equations (4a) and (5a) in Table 10-9. These estimates lie very close to the actual values I_t^*, but they tend to lag behind the latter at turning points by one-quarter intervals. Such lags, of course, are typically associated with regressions that include lagged values of the dependent variable. The estimates from the two equations are closely similar, but (5a) has a marginal advantage, which is also reflected in the summary measures of Table 10-9, columns 6–8. While the (4a) estimates show one-quarter lags at all eight recorded turns in I^*, the (5a) estimates show such lags at six and coincident timing at two of the turns (the troughs of 1958 and 1961).

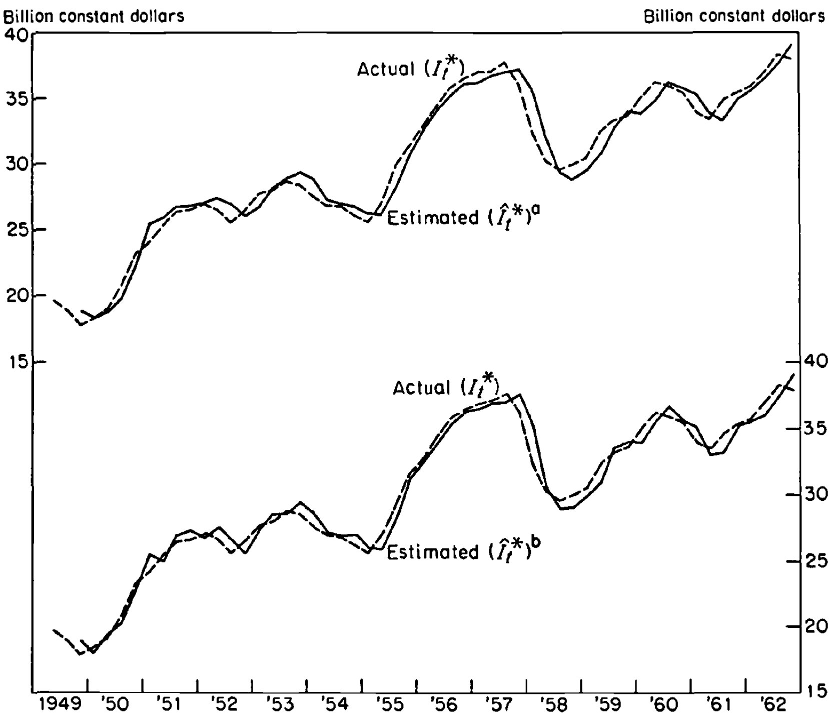
Clearly, one must expect I_t^* to be less closely associated with the estimates of OC^*_{t-i} than with the actual values. My calculations suggest that the differentials in these effects are substantial. Moreover, in the equations with observed values, OC^* performed well when entered

Chart 10-4

Regressions for Business Fixed-Investment Outlays in Constant Dollars, Based on Distributed Lags with Estimated Commitments, Quarterly, 1949–62

(a) $\hat{I}_t^* = -.462 + .140\hat{OC}_{t-1}^* + .861 I_{t-1}^*$

(b) $\hat{I}_t^* = .942 + .052\hat{OC}_{t-1}^* + 1.396 I_{t-1}^* - .483 I_{t-2}^*$



with the subscripts $t-2$ or even $t-3$, as shown in Table 10-3, while here $\hat{OC}^*$ must be used with the subscript $t-1$.[53]

To replace actual commitments by the estimates means in effect to replace new investment orders and contracts by a linear combination

[53] It will be recalled that several causal variables taken with subscripts $t-1$ make significant contributions in regressions for I^* when included along with OC_{t-2}^* or OC_{t-3}^* (Table 10-3). Now $\hat{OC}_{t-1}^*$ might reflect to some extent these influences, while $\hat{OC}_{t-2}^*$ would not. When $\hat{OC}_{t-1}^*$ is excluded from the equations of Table 10-9, the re-estimated coefficients of $\hat{OC}_{t-2}$ are positive but barely significant. That $\hat{OC}^*$ must be taken with a shorter lead relative to I^* than was applicable to OC^* offsets the potential gain of a longer predictive span that would result from the substitution of estimated for the actual commitments.

of selected "causal" variables or a sum of their estimated influences. The present results and related earlier findings suggest that the anticipatory data definitely contain more information about subsequent investment expenditures than do the causal factors. Perhaps further efforts will produce substantially better specifications which would permit a revision of this verdict, but the prospect seems to me rather doubtful.

With all the necessary qualifications, a modest success can probably be claimed on behalf of the estimated values of OC^*. There is indeed some reason to appreciate the very fact that they remain measurably influential in equations for I^* that also include the powerful effects of the lagged values of the dependent variable. Not only that, but the average lags implied by the estimates of Table 10-9 are consistent with the evidence reviewed in the preceding sections. Taking into account the one-quarter leads of the causal variables in (C1), the average lags of I^* relative to these variables are 7.2 according to equation (4a) and 5.9 quarters according to (5a).

Concluding Remarks

The rather crude aggregate intended to approximate orders and contracts for capital goods is demonstrably associated with several series that can be taken to represent factors influencing private decisions to invest in plant and equipment. The associations are of the type consistent with familiar hypotheses of investment determination. These hypotheses are general, and their formal structure has not yet been worked out adequately. In particular, we know far too little about how the relevant expectations are formed. Investment decisions relate to the expected time-paths of such variables as sales, profits, and interest rates rather than to their past levels or changes; yet it is the past values which alone are known and must serve as proxies for the expectations that are not observable. However, some of the proposed explanatory variables may be more "proxy" than others, in the sense that their theoretical meaning is less clear and that they are likely to prove of little (if any) importance once the other factors are more properly accounted for. Especially, attempts have been made in some recent studies to reduce profits to the role of a proxy variable for the pressure of demand on capacity.[54] The literature makes it only too clear that these

[54] The main proponent of this view is Robert Eisner (see references in note 46, above). However, the evidence on this point is quite mixed. To quote Eisner: "While coefficients of the profit variables

problems are very difficult to handle with the available data and techniques; fortunately, it is not improper to place them outside the scope of this inquiry.

Indeed, in asking whether the constructed order-contracts series fits into the framework of suppositions adopted to explain investment, one is "testing" the data perhaps as much as the hypotheses. An exploratory and experimental approach seems appropriate at this point, despite its lack of rigor. The analysis bears on important issues and should at least give useful hints for further research. Thus it is suggestive that the variables associated with the flexible-accelerator hypothesis work rather better when applied to investment orders than when applied to investment expenditures; that the profit variables are nevertheless still significant (the capacity and profit "principles" need not be mutually exclusive); and that the influence of interest rates conforms to expectations.

As shown in Chart 10-1 and documented later (Chapter 12), new investment orders and contracts turn down well ahead of peaks and turn up before the troughs in general economic activity. In fact, this variable (*OC*) is an important "leader" that precedes many other economic aggregates and follows few. Most of the series suggested as possible "explanatory" variables for the investment commitments function lag behind rather than lead *OC* at turning points; it does not seem likely that they could represent the critical factors in the determination of the early timing of *OC*. However, the changes in profits and sales and the interest rates (inverted) do often turn ahead of new investment commitments as do sometimes also corporate profits proper. The latter appears to be more closely associated with new investment orders and contracts than any other variable examined, as far as the cyclical behavior of the commitments series is concerned.

Some variables that have recently been treated as potentially important determinants of investment were not included in my analysis. Grunfeld (see note 45) has argued that the "market value of the firm" provides a preferable indicator of the expectations governing in-

are uniformly low in cross sections, they are relatively high in most of the time series. Firms apparently tend to make capital expenditures in the period immediately following higher profits, but firms earning higher profits do not make markedly greater capital expenditures than firms earning lower profits. This evidence is consistent with the hypothesis that past profits play some significant role in the timing of capital expenditure but do not affect its long-run average." ("A Permanent Income Theory," p. 386). Since the principal interest of the present study is in the short-term behavior of investment on aggregative levels, my direct concern here is with the time series aspects of the relations involved.

vestment decisions, which suggests that a stock market variable ought to be included in the analysis of orders for plant and equipment. Recent tests indicate that the stock price index makes a significant but not major contribution to the explanation of fixed-investment expenditures.[55] It seems unlikely that this factor will prove much more forceful as an early determinant of investment orders and contracts; moreover the chain of influence in the opposite direction—from orders to stock prices—may also be important, and could disturb this relation.[56] But these matters have yet to be investigated.

Recent studies by Jorgenson and associates provide support for a "neoclassical" model of investment behavior, in which a complex synthetic variable is employed to represent the price (or user cost) of capital services. These contributions, to which references were made before, appeared too late for tests based on Jorgenson's model to be included in this study.

According to a monetary view of business cycles, variations in the rate of growth of the money stock are a major source of changes in spending on current and future output (including consumption as well as investment expenditures).[57] If the rate of change of the money stock is treated as conforming positively to business cycles, its turning points are found to lead at peaks and troughs by long, though variable, intervals. The transmission mechanism involves adjustments in the demands

[55] Griliches and Wallace, "Determinants of Investment Revisited," p. 326, use the Standard and Poor's index of industrial stock prices as of the end of quarter $(t-2)$ and find that past output and interest rates had stronger effects on gross investment in plant and equipment. Meyer and Glauber, *Investment Decisions*, Chap. VII, conclude that the S&P index changes do reflect "an expectational influence at work in business investment decisions," but note that introduction of this variable greatly aggravates the collinearity problem, which is generally serious and difficult in time series regressions for investment; that it is not clear at all how to deflate the stock price index; and that the latter's positive contribution to the explanation of investment occurs chiefly during periods of expansion when the internal funds variable is ineffective (*ibid.*, pp. 152–53 and 172). Christ, *Econometric Models and Methods*, also finds the stock price variable to have a significant positive effect on investment expenditures. D. W. Jorgenson and C. D. Siebert ("Theories of Corporate Investment Behavior," *American Economic Review*, September 1968, pp. 681–712) rank the factor of firm value ("expected profits") as stronger than the accelerator and liquidity factors but weaker than the value of output deflated by the price of capital services (the "neoclassical" variable). For some theoretical objections to the use of market value (as well as profits) as an indicator of desired capital stock, see John P. Gould, "Market Value and the Theory of Investment of the Firm," *American Economic Review*, September 1967, pp. 910–13.

[56] For example, "declines in the level or rate of growth of profits or in factors portending such declines— . . . profit margins . . . or new orders . . . —during the latter stages of business cycle expansions may alter appraisals of common stock values and hence produce a decline in stock prices before the downturn in business" (Geoffrey H. Moore, ed., *Business Cycle Indicators*, Princeton for NBER, 1961, Vol. I, p. 68).

[57] For a summary of this position, see Milton Friedman and Anna J. Schwartz, "Money and Business Cycles," *Review of Economics and Statistics*, Supplement, February 1963.

for, and prices of, various assets, although the early impact is mainly on financial assets. This view implies a causal connection between money and investment and suggests the inclusion of monetary variables in the regression analysis of orders and contracts for capital goods. But the suggested transmission process includes complex intermediate links and lags that may be long and are probably quite variable; the whole subject is as yet little explored and little understood. It is doubtful that the present analysis would gain much if it simply included a measure of monetary changes, but a systematic investigation of the relations involved lies beyond its scope. Of course, monetary changes strongly influence several of the causal variables used in this study, notably the interest rates and the cash flows or internal funds available for investment.

Orders and contracts provide an important link in the analysis of business investment in plant and equipment. It is important to recognize that the latter is a time-consuming process and to utilize this insight in research and prediction. There is need for better data on the early investment stages. Thus a "cleaner" series on new orders for capital goods should contribute substantially to the improvement of analysis and forecasting in this area. That much can be said with considerable assurance, and it is worth emphasizing.

Summary

Business expenditures on plant and equipment (I), taken with appropriate lags, are closely associated with new capital appropriations (App), new investment orders and contracts (OC), and "first anticipations" (A_1). The correlations of I with any of these anticipatory or symptomatic variables tend to be considerably higher than the correlations of I with any of the several "causal" variables that are suggested by various hypotheses about investment determination. In multiple regressions that include both the symptomatic and the causal variables, the former contribute in general more to the statistical explanation of I than do the latter. The causal variables include some that are associated with the flexible-accelerator hypothesis, some that provide proxies for expectational elements and measures of financial factors, and some that stand for the opportunity costs involved. The hypotheses considered are not mutually exclusive and none are decisively refuted by this regression analysis.

If the causal variables in the equations for I_t represent factors that influence investment *decisions,* then they should, when taken with earlier timing, contribute significantly to a statistical explanation of OC_t. In general, they do this, but in different degrees and with important qualifications. It is not difficult to obtain rather good fits for OC, but the best fits result from using simultaneous relationships or short leads of the explanatory variables. The regressions for I_t yield higher $\bar{R}^2$ coefficients with longer predictive leads. As would be expected, OC with its early timing pattern is a good predictor of expenditures but is itself much more difficult to predict.

Final sales, capital stock, profits, and the long-term interest rate together account for 78 per cent of the variance of new investment commitments, when deflated series and one-quarter leads of the independent variables are used. The coefficients of capital stock and of the interest rate are negative; the others are positive. The early cyclical timing of OC is captured rather well in these estimates, owing to the contributions of the profit and interest variables. Of the lagged values of the dependent variable, only OC_{t-1} improves the results significantly. When the explanatory factors are taken with longer leads relative to OC_t, the goodness-of-fit statistics become much less favorable.

The distributed-lag regressions suggest that half or more of the total volume of new investment commitments are incurred in the first six or nine months following a shift in the factors that influence investments decisions. The lags in reaching the decision to go ahead with an investment project are not very long, according to these estimates. This result is believed to be plausible and consistent with other acceptable evidence.

To calculate the average time that outlays on plant and equipment require to register major changes in response to changes in the determinants of investment decisions, one must combine the lag of OC behind the latter factor and the lag of I behind OC. According to my estimates in this and the preceding chapter, the combined average lag varies between approximately five and eight quarters.

Other quarterly regression studies yield for the most part about the same range for the estimates of the average lag between the change in the demand for capital stock and fixed-investment expenditures. This similarity is limited to the averages, as the studies use different forms of lag distribution. In contrast, regression studies based on annual data suggest average lags that are exceedingly long (up to 7–10 years). The estimates of such protracted lags are contradicted by independent evidence from surveys of new investment projects, and it is difficult to justify or accept them.

Calculated series of new investment commitments, $\widehat{OC}$, perform fairly well in selected distributed-lag equations for I, but they are much less effective in this role than the corresponding series of *actual* commitments, OC. This confirms that the data on new orders and contracts for plant and equipment, despite their undoubtedly considerable weaknesses, contain definitely more information about subsequent capital expenditures than do several presumably important causal variables linearly combined.