This PDF is a selection from an out-of-print volume from the National Bureau of Economic Research

Volume Title: Orders, Production, and Investment: A Cyclical and Structural Analysis

Volume Author/Editor: Victor Zarnowitz

Volume Publisher: NBER

Volume ISBN: 0-870-14215-1

Volume URL: http://www.nber.org/books/zarn73-1

Publication Date: 1973

Chapter Title: Orders, Production, and Inventory Investment

Chapter Author: Victor Zarnowitz

Chapter URL: http://www.nber.org/chapters/c3555

Chapter pages in book: (p. 344 - 408)

8

ORDERS, PRODUCTION, AND INVENTORY INVESTMENT

THERE ARE THREE major sections in this chapter. The first is a theoretical discussion of the major determinants of purchasing and inventory behavior. The second, a critical survey of recent work in inventory analysis, concentrates on the role of orders and related factors and on the importance of disaggregation by type of production and stage of fabrication. The third assembles and evaluates additional evidence on the relations that underlie the cyclical fluctuations of inventories.

Determinants and Patterns of Inventory Behavior

Relations with Sales and Orders Placed and Outstanding

We will consider orders relating to goods that are to be resold by the buyer in unchanged physical form, e.g., orders for a consumer good received by the producer from the distributor.[1] Let us suppose that we have data for the *purchasing firm* on (1) the sales of the product in each consecutive planning period ("month"); (2) the orders for the product placed by the firm each month with its suppliers; (3) the volume of such orders outstanding at the end of each month; and (4) the stock of the product in possession of the firm at the end of each month. To abstract from problems of measurement and aggregation, assume that all these series are in homogeneous physical units of the given

[1] Some of what follows can, with modifications, be applied to the buying of goods to be resold after processing, e.g., to materials purchasing by the manufacturer. The restriction adopted above will help to keep the analysis simple. Investment in purchased materials will be taken up in the following section.

good. A number of different models based on such data can be devised, embodying certain more or less simple assumptions about the relations among the four variables. The few such models presented here, while no doubt highly oversimplified, are nevertheless instructive (see Chart 8-1 and Table 8-1).

The simplest inventory objective for the firm is to maintain a constant stock of the item in each period, say $\bar{F} = 200$ units. This assumption underlies the four models designated I, Ia, Ib, and Ic in Chart 8-1. In the second group of models, labeled II through IIc, the assumed objective is a constant stock-to-sales ratio with $\overline{F/S}$ equal to 2. The models start in each case from a given cyclical time-path of sales (S). In all models except Ia and IIa, this path is identical and embodies retardations of sales at the peaks and troughs. In models Ia and IIa sales paths show sharp downturns and upturns not preceded by retardations.

In models I, Ia, II, and IIa, the delivery period and outstanding orders are zero. The firm places all its orders at the end of the month after having determined the amount of the product it has sold and the inventory it has left. All these orders are supplied at the beginning of the next month. The actual change in inventory in month t equals new orders placed (OP) in $(t-1)$ minus sales in t: $\Delta F_t = OP_{t-1} - S_t$. Hence, the actual inventory $F_t = F_{t-1} + OP_{t-1} - S_t$.

In the other models a positive delivery lag is introduced, resulting in the appearance of positive outstanding orders. It is assumed that $\Delta F_t = OP_{t-2} - S_t$. The delivery lag is constant, and outstanding orders simply equal the total of new orders issued in the month just ending and the month preceding: $OU_t = OP_t + OP_{t-1}$.

Orders placed equal the sum of current sales and a correction element C: $OP_t = S_t + C_t$. The corrective component C equals the inventory error, i.e., the discrepancy between desired and actual inventory, which is, in each of the models, a function of changes in sales (ΔS). In the simplest case, C_t just equals ΔS_t (models I and Ia); elsewhere, it may be the sum of current and past sales changes (Ic), a multiple of the current change (II), or some more complicated function.[2]

[2] In model I we have $C_t = \bar{F} - F_t$; hence $\Delta C_t = \Delta F_t$. But $\Delta F_t = OP_{t-1} - S_t$, and $OP_{t-1} = S_{t-1} + C_{t-1}$. Therefore, by substitution, $\Delta C_t = S_t - S_{t-1} - C_{t-1}$, which reduces to $C_t = \Delta S_t$.

In Ic, analogously, $\Delta C_t + \Delta C_{t-1} = -\Delta F_t = S_t - OP_{t-2} = S_t - S_{t-2} - C_{t-2}$, which reduces to $C_t = \Delta S_t + \Delta S_{t-1}$. In Ib, the relation is somewhat more complicated. It can be shown that $C_t = \Delta S_t + \Delta S_{t-1} + \Delta C_{t-1}$. The counterpart of this for type II models is shown in the text and note 3, below.

It follows that orders placed depend on the level of sales and on changes in sales. The latter corrective component imparts to the behavior of orders (in relation to sales) the well-known characteristics of acceleration and magnification. For cyclically fluctuating series such as sales, levels and changes are positively correlated. Hence orders, being directly related to both the level of and the first differences in sales, exceed sales in amplitude of fluctuation (compare the curves *S* and *OP* in the upper panels of Chart 8-1). But there are differences. The magnification of the movement of orders in comparison with product sales is greater in the models with a delivery lag than in those

Chart 8-1
Cyclical Time-Paths of Sales, Orders Placed and Outstanding, and Product Inventory in Eight Hypothetical Models

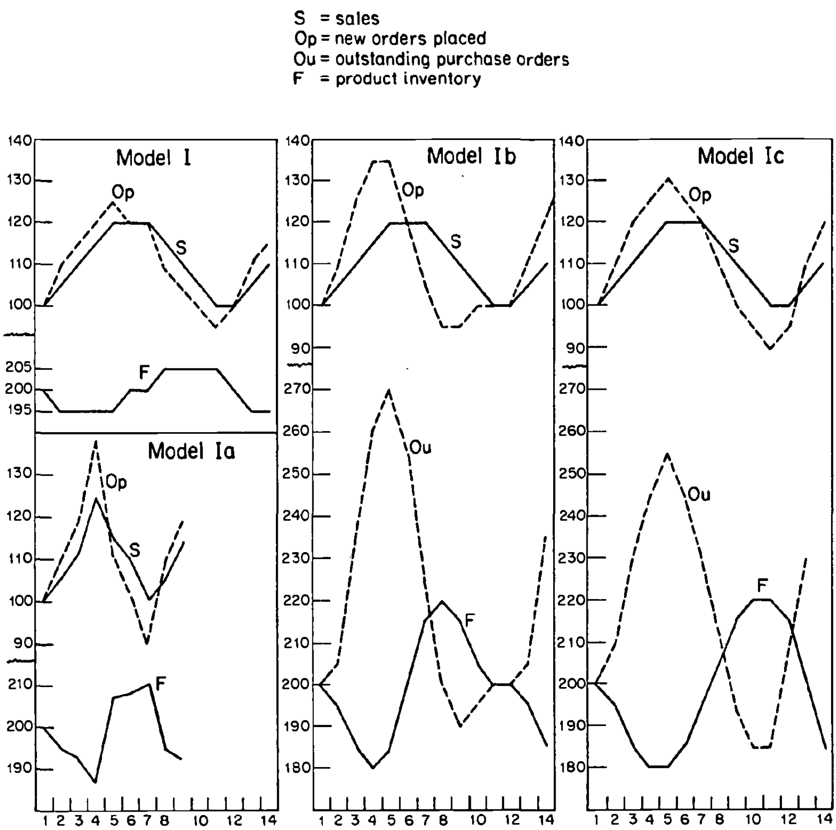
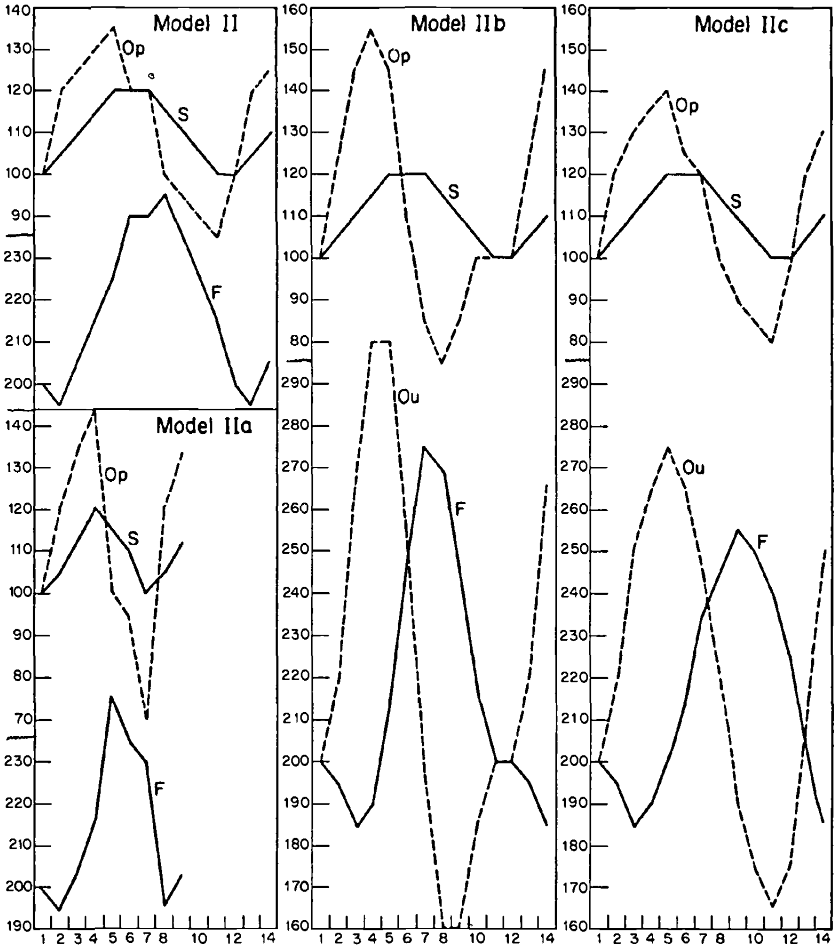


Chart 8-1 (concluded)



Note: For explanation of models, see text.

without it (compare models Ib and Ic with I; and IIb and IIc with II). This is reasonable. The interval between the ordering of a good and its delivery and sale has lengthened, while the firm's buying is still based on a simple extrapolation of (unchanged) sales and on the correction factor. The range of the inventory error to be reversed by the corrective orders has increased, and this alone amplifies the movement of orders placed.

Table 8-1

Data Input and Output for Eight Models of Sales-Orders-Inventory Relations

Variable and Model[a]	Period[b] 1	2	3	4	5	6	7	8	9	10	11	12	13	14
SALES (S)[c]														
I, Ib, Ic; II, IIb, IIc	100T	105	110	115	120	120	120P	115	110	105	100	100T	105	110
Ia	100T	105	112	125P	115	110	100T	105	112					
IIa	100	105	112	120P	115	110	100T	105	112					
NEW ORDERS PLACED (OP)														
I	100	110	115	120	125P	120	120	110	105	100	95T	100	100	115
Ib	100	110	125	135	135P	120	105	95	95T	100	100	100	110	125
Ic	100	110	120	125	130P	125	120	110	100	95	90T	95	110	120
II	100	120	125	130	135P	120	120	100	95	90	85T	100	120	125
IIb	100	120	145	155P	145	110	85	75T	85	100	100	100	120	145
IIc	100	120	130	135	140P	125	120	100	90	85	80T	95	120	130
Ia	100	110	119	138P	111	102	90T	110	119					
IIa	100	120	133	144P	100	95	70T	120	133					
INVENTORY (F)[d]														
I	200	195	195	195	195T	200	200	205	205	205	205P	200	195	195
Ib	200	195	185	180T	185	200	215	220P	215	205	200	200	195	185
Ic	200	195	185	180	180T	185	195	205	215	220	220P	215	200	185
II	200	195T	205	215	225	240	240	245P	235	225	215	200	195T	205
IIb	200	195	185T	190	215	250	275P	270	245	215	200	200	195	185T
IIc	200	195	185T	190	200	215	235	245	255P	250	240	225	200	185T
Ia	200	195	193	187T	207	208	210P	195	193					
IIa	200	195T	203	216	245P	235	230	195T	203					
OUTSTANDING ORDERS (OU)[d]														
Ib	200	210	235	260	270P	255	225	200	190T	195	200	200	210	235
Ic	200	210	230	245	255	255P	245	230	210	195	185	185T	205	230
IIb	200	220	265	300	300P	255	195	160	160T	185	200	200	220	265
IIc	200	220	250	265	275P	265	245	220	190	175	165T	175	215	250

Notes to Table 8-1

P = peak; T = trough. In the case of high or low plateaus of equal value, the last standing is taken to be the peak or trough.

[a] The models are divided into three groups: (1) models I, Ib, and Ic; (2) models II, IIb, and IIc; and (3) models Ia and IIa. For definition and explanation of the relationships involved, see text.

[b] In each line, the series is carried through a sufficient number of periods to complete a full trough-to-trough or peak-to-peak cycle. Trends are not assumed, and the cycles (which are not necessarily symmetrical) are supposed to recur periodically without change. The series are shown for two periods after they regain their initial values. For the graphs of these series, see Chart 8-1.

[c] The sales variable is exogenous—a given input to each model. The other variables all depend on the levels and rates of change of sales in various combinations and with various lags.

[d] End of month.

The amplitude of the corrective orders, and therefore (given the course of sales) of total orders placed, will also be greater for a firm that chooses to have stocks change in proportion to sales than for a firm that wishes to keep stocks at a constant level. This is so because the former plans its ordering so as to provide not only for the replacement of what was sold last month but also for the replenishment or reduction of the stock to the desired ratio $\overline{F/S} = \mu$. In model II, the corrective factor C_t is equal, not to ΔS_t as in model I, but to $(\mu + 1)$ ΔS_t, or in our illustrative case, $3\Delta S_t$.[3] The multiplier $(\mu + 1)$ is necessarily positive and larger than unity; therefore, the excess of the amplitude of *OP* over that of *S* must be greater in model II than in model I.

Orders placed will lead sales if the latter show retardations, i.e., ΔS turning earlier than *S*, for then *C* will show the same early timing as ΔS, causing *OP* to lead *S*. Accordingly, Chart 8-1 shows that new orders lead sales at either turn in each of the models, except in Ia and IIa where there is no sales retardation and therefore *OP* and *S* have coincident timing.

In models Ib and IIb, the attempts to adjust the inventory to the

[3] From

$$F_t = F_{t-1} + OP_{t-1} + S_t$$

and

$$OP_{t-1} = S_{t-1} + C_{t-1} = S_{t-1} + \mu S_{t-1} - F_{t-1},$$

we obtain by substitution $F_t = (1 + \mu)S_{t-1} - S_t$; and

$$C_t = \mu S_t - (1 + \mu)S_{t-1} + S_t = (1 + \mu)(S_t - S_{t-1}).$$

desired level are made only through current corrective orders without regard to the effect of orders that have already been issued and are still to be delivered. But Ruth Mack's study of the practices in the shoe trade supports the view that businessmen will not order in any given month the whole amount by which the actual stock fell short of the desired stock (or cancel outstanding orders to the extent of the full excess of the desired over the actual stock). Instead, they will take account of those outstanding orders that they have placed previously, with the intention of raising or reducing inventory to the desired level.[4] For example, C_t will then no longer be just $200 - F_t$ as in models I, Ia, and Ib, but will instead equal $(200 - F_t) - C_{t-1}$. This is the assumption embodied in model Ic. Similarly, in IIc the inventory error $(2S - F_t)$ is offset, not by C_t (as in II, IIa, and IIb), but rather by $C_t + C_{t-1}$.

As a result of this allowance for outstanding orders, the movement of *OP* is somewhat smoothed and its amplitude reduced. The lead of *OP* at turns in *S* may also be shortened a little (compare models Ic and IIc with Ib and IIb, respectively).

The only substantial body of direct data on orders placed and outstanding is found in the Federal Reserve Board reports on merchandizing activities of department stores. A comparison of new orders issued by the department stores (*OP*) with sales of the same stores (*S*) shows that: (1) The short-term fluctuations in *OP* are always much larger than those in *S*; and (2) the timing of *OP* and *S* is roughly synchronous but *OP* sometimes leads *S* by short intervals.[5] These findings are broadly consistent with what the model relationships would lead one to expect.

Stocks (*F*) definitely lag behind sales in all our models. Where constant inventory is desired (I–Ic), the lags are so long that *F* and *S* frequently move in opposite directions. Where planned inventory is proportional to sales (II–IIc), the lags are shorter, and the relation is more positive. The relations between stocks and outstanding (and new) orders are essentially inverted (see Chart 8-1).

[4] See Ruth P. Mack, *Consumption and Business Fluctuations: A Case Study of the Shoe, Leather, Hide Sequence*, New York, NBER, 1956.

[5] See Ruth P. Mack and Victor Zarnowitz, "Cause and Consequence of Changes in Retailers' Buying," *American Economic Review*, March 1958, Table 1, p. 26. Some more up-to-date charts of the department store series can be found in Ruth P. Mack, "Changes in Ownership of Purchased Materials," in Joint Economic Committee, *Inventory Fluctuations and Economic Stabilization*, 87th Cong., 1st sess., 1961, Part II, pp. 77 and 81.

Stocks undoubtedly lag behind sales in the department store data: They lagged at each of the six turns in sales in 1941–54. But the lags were not long (they averaged 2.3 months), and the relation was basically positive rather than inverted.[6] Relative to orders placed and outstanding, stocks show longer lags and correspondingly somewhat stronger inverted characteristics. Here the evidence is less favorable to our models but on the whole still not inconsistent with them.

Factors Influencing Purchases and Stocks of Materials

Consider now the purchase of goods for use in production rather than resale. Inventory of purchased materials (M) increases when orders for materials placed by the firm (OM) are filled, that is, are translated into deliveries to the firm (DM). Inventory M decreases when materials are withdrawn as input for production (IN). Therefore,

$$M_t = M_{t-1} + DM_t - IN_t. \quad (1)$$

If the materials are supplied with delivery lag k, then $OM_{t-k} = DM_t$; so

$$M_t = M_{t-1} + OM_{t-k} - IN_t. \quad (1a)$$

Outstanding orders for materials (OUM) increase (decrease) when orders placed exceed (fall short of) receipts, that is,

$$OUM_t = OUM_{t-1} + OM_t - DM_t. \quad (2)$$

Substituting the order terms from (2) for DM_t in (1), one gets

$$M_t = M_{t-1} + OUM_{t-1} - OUM_t + OM_t - IN_t. \quad (3)$$

Following Ruth Mack, the sum of inventory and outstanding orders for materials will be called the "ownership" of purchased materials. Let this aggregate of stocks on hand and on order be denoted as $OWM_t = M_t + OUM_t$. Then (3) can be rewritten as

$$OWM_t = OWM_{t-1} + OM_t - IN_t. \quad (3a)$$

Definitional equations such as these of course tell us nothing directly about human behavior or testable economic relationships, but they can help to identify the roles of the variables concerned and to avoid some omissions and inconsistencies. Thus (3) and (3a) suggest that it is not

[6] Mack and Zarnowitz, "Cause and Consequence."

only the levels and changes of stocks on hand that matter in the analysis of investment in purchased-materials inventories, but also the levels and changes of stocks on order (outstanding purchase orders).[7]

The models of the preceding section suggest that sales-related goals and variables have a central role in shaping the changes in inventories. While sales have been treated as exogenous, this is clearly not necessary; for example, sales expectations based on past sales behavior could well be explicitly introduced.[8] In the equations for materials, it is the productive inputs (IN) that have a role analogous to that of sales (S) in the earlier models. The materials stock (M) here corresponds to the "product inventory" (F) there, and the orders variables, OM and OUM, correspond to OP and OU, respectively. By substituting M for F, etc., the models could, *mutatis mutandis*, be adapted to reflect the relations among materials stocks, inputs, and orders. The magnification and acceleration effects would then be observed in the comparison of movements in IN and OM; also, stocks on order would again be found to move ahead of stocks on hand.

The rates of utilization for materials (IN) depend primarily on the planned production and its requirements. In manufacture to order, the scheduling of production is geared to orders received, their terms of delivery, and the progress of work on them: in other words, to the relevant dimensions of the firm's unfilled commitments to its customers. Manufacturers' shipments are closely correlated with output, and they can be fairly well estimated as weighted totals of past, and perhaps also current, inflows of new orders (Chapter 5). Hence, these order receipts, N_{t-i}, along with the distribution of the product delivery lags i, provide the main guide to the estimates of future output and of the associated materials inputs (IN).

In production to stock, sales anticipations S^a are presumably the main factor in short-term production planning. While "autonomous" expectations based on some "inside knowledge," guesswork, hopes, and the like, are probably often involved in the formation of S^a, the major observable determinant here is past sales experience. That is,

[7] This point received early and strong recognition in the writings of Ruth P. Mack (see notes 4 and 5, above).

[8] In a "complete" macro model, sales would be taken to depend on total output or income, and a feedback effect of inventory investment on sales and income would be included. Such models have been developed in the basic and influential articles by Lloyd A. Metzler, "The Nature and Stability of Inventory Cycles," *Review of Economic Statistics*, August 1941, and "Factors Governing the Length of Inventory Cycles," *ibid.*, February 1947; and Ragnar Nurkse, "The Cyclical Pattern of Inventory Investment," *Quarterly Journal of Economics*, August 1952.

S^a is likely to be, in large part, some extrapolation of actual sales, that is, of the value of new orders received and shipped ($S_{t-i} = N_{t-i}$). Once more, then, IN is seen as a function of N_{t-i}; but new orders clearly make a much less dependable guide here, where they are filled from stock rather than from future output.[9] In production to stock, errors of sales forecasts will inevitably occur and they imply the existence of a passive or unintended component of the investment in materials (which, in turn, may give rise to corrective elements in materials purchasing). In contrast, errors of sales forecasts are nonexistent in the extreme case of pure production to order.

Given the state of technology in the broad sense (involving business organization as well as physical production and transportation constraints), the aggregate stock of materials on hand and on order can be viewed as being in the first place a positive function of the rates of scheduled output. Thus a certain level of materials "ownership," say $\overline{OWM}$, will be necessary to maintain a certain rate of production, say $\bar{Z}_t$. In this hypothetical stable state, purchase orders would be placed at a rate, $\overline{OM}_t$, that balances IN_t, the required rate for the input of materials into production or, more strictly, the transformation of materials into "goods in process" [see equation (3a), above]. The positive association between the desired levels of OWM and Z implies that net investment in materials stocks on hand and on order is similarly related to the rate of change in output.

Even in this rudimentary form, the above argument is not simply equivalent to the accelerator hypothesis that links inventory investment to output changes. It is consistent with a lag of materials stocks behind the level of output and with a lag of investment in these stocks behind the change in output. Such lags may occur because of delays in the recognition of changes in the demand for output (in production to stock) or because of delays in filling the purchase orders by the suppliers of materials (in production to stock or to order). Stocks on order would not be expected to show the same lagging tendencies, since they can probably be adjusted more easily and promptly than stocks on hand.

Moreover, there are other important aspects and motivations of inventory investment. The observed changes of inventory in successive short periods may represent only partial adjustments toward the "de-

[9] Compare the discussion of sales anticipations and the predictive properties of new orders in the last section of Chapter 2.

sired" inventory level because of the effects of uncertainty and the costs involved in making larger and more abrupt changes. This notion, when combined with the view of the desired inventory as essentially a function of sales or output, leads to the "flexible accelerator" models that have been widely used in recent aggregative studies of inventory behavior. But intended inventory can be related to other variables as well, notably the expected changes in prices and availability of the goods to be purchased and the cost of financing and holding the inventory (usually represented by short-term interest rates).

To sum up, what happens to the stocks of materials on hand and on order (M and OUM) depends upon: (1) the demand for the outputs of the firms that purchase M; this can be represented by some weighted function of the N_{t-i} terms; (2) the reactions of the purchasing firms to changes in N; these are expressed in OM, the flow of orders placed by the firms with the suppliers of materials; (3) the performance of the suppliers, as reflected in the relation between OM and the deliveries of materials (= materials orders received, DM); the delivery lags involved (k) may vary with business conditions. Of the variables listed, OM is the most readily controlled. Consequently, it reflects best the intentions of the firms that invest in materials.

A firm needs to hold some inventory of materials to be competitively efficient in production; to keep the delivery periods (i) for its products reasonably short; to handle discontinuities in the flow of demand and output; and to be protected against irregularities in the performance of the suppliers (such as delays in delivery, i.e., increases in k). Our understanding of how each of these motives works would be greatly enhanced by knowledge of the relations between sales orders received and purchase orders placed. Unfortunately, data that are essential for the study of these relations are lacking, since statistics on orders placed and outstanding, by industries or product categories, are generally not available.[10]

The Role of Changes in Supply Conditions

Unfilled orders for the market categories of "materials, supplies, and intermediate products" equaled from one to three months' worth of current shipments in the period 1953–66 (see Chart 6-6 and related

[10] The argument that purchase orders data are greatly needed for a more fruitful analysis and better understanding of inventory fluctuations has been made repeatedly and forcefully by Ruth Mack. For the most recent formulation, see Ruth P. Mack, *Information, Expectations, and Inventory Fluctuation: A Study of Materials Stock on Hand and on Order*, New York, NBER, 1967, p. 293.

text). Evidence based on timing comparisons of new orders and shipments (Chapter 4) supports these indications of generally prompt availability of materials supplied by the domestic factories. Raw materials from domestic nonmanufacturing sources can apparently also in large part be procured without major delay.[11] Imported goods and commodities of agricultural origin have on the whole larger or more variable delivery lags, but these categories carry much less weight than the materials from domestic and industrial sources.

It appears, therefore, that purchases of goods to be processed involve for the most part relatively short delivery periods; to a large extent, they are serviced promptly from the seller's stock. This is not surprising, since such goods are as a rule highly standardized. Similar statements can also be made about most of the goods purchased to be resold. The *U/S* ratios are indeed extremely low (less than 1) for the market category of "home goods, apparel, and consumer staples" (Chapter 6). Consistent evidence of the shortness of the average delivery periods on goods bought by retailers is provided by department-store data.[12]

Moreover, timely delivery of standardized goods bought to be processed or resold is enforced by competitive conditions. Efficient operation of the buyer's business will often require that he be assured of prompt supplies. There is, therefore, strong demand for these goods to be available when needed. If that demand cannot be satisfied by a seller, he may well lose the order to a competitor who can.

An important implication is that purchasing for inventory is likely to be significantly influenced by the conditions of supply as viewed and anticipated by the buyer. He will endeavor to avoid any unusually long delivery delays for his inputs, as well as price increases, which he knows are often associated with tightened supply conditions. If delays and difficulties in getting supplies should arise, this is likely to be signalized by an accumulation of unfilled orders on the suppliers' books. Buyers may watch for such signs, and try to place additional orders in time to protect themselves against the possibility of shortages and price increases in the near future. But in the aggregate, the process can become cumulative and self-defeating. In a full-grown expansion, as

[11] On this and the following statement, see Moses Abramovitz, *Inventories and Business Cycles with Special Reference to Manufacturers' Inventories*, New York, NBER, 1950, Chap. 9.

[12] On the average, in 1941–54, receipts of (deliveries of merchandise to) department stores lagged behind new orders placed by these stores by a little less than one month. See Mack and Zarnowitz, "Cause and Consequence," Table 1, p. 26.

suppliers approach capacity operations they begin to quote longer "lead times" to their customers. To the extent that the latter respond by placing more orders in an attempt to increase their stocks on order, their actions, designed to alleviate the problem for the individual firm, are apt to aggravate the total problem. As the additional orders only succeed in swelling the suppliers' backlogs, they actually result in an intensified excess demand situation of which the increases in backlogs, delivery lags, and prices are primary symptoms.

However, some stabilizing forces are also at work in this process. Buyers basically prefer shorter delivery periods, and the competition among producer-sellers works toward satisfying this preference. Price increases may deter some buying. Moreover, just as the buyers watch the backlogs of the suppliers, so may the latter watch the materials stocks of the buyers. When these stocks run low, suppliers are likely to expect an expansion of customer orders and might prepare for it in various ways. Production to stock, in anticipation of the rise in orders, would be one such way, and would have a stabilizing effect.[13]

During contractions, conversely, sales decrease and with them the desired levels of stocks on hand and on order. Firms accordingly reduce their current purchases, thereby gradually liquidating their outstanding orders, which are also the unfilled commitments of their suppliers. The delivery periods are thus cut back to their normal levels, which for much of inventory buying means immediate availability or very short lead times. As the downward adjustment of stocks is completed, there is no more reason for further reduction of purchases, unless sales continue declining. But in the early stages of contraction, the cessation of advance buying will have motivated some inventory disinvestment and contributed to the business decline.

The interaction of changes in buyers' anticipations and ordering and of changes in supply conditions has long been neglected by the inventory theory. The theme has, however, received considerable attention in some recent studies.[14]

[13] It should be noted, however, that large customer stocks are a phenomenon associated with production to order. (The major example is steel products, which are largely manufactured to order and the inventories of which are heavily concentrated in user hands.) In industries that are predominantly engaged in manufacture to order, low levels of customer-held stocks may not be a sufficient inducement for the producers to switch, on a large scale, to production to stock.

[14] In addition to the previously cited books by Mack and the article by Mack and Zarnowitz, see Thomas M. Stanback, Jr., *Postwar Cycles in Manufacturers' Inventories*, New York, NBER, 1962.

The Effects of Backlog Changes

The preceding discussion of the effect of changes in supply conditions and anticipations on buying of materials and stocks in trade would lead one to predict a positive association between backlog changes and inventory investment. Such a relation has indeed been repeatedly observed, but in a form which admits (or even demands) a different interpretation.

Manufacturers who accumulate unfilled orders can look forward to increased sales and, to the extent that the backlogs represent firm commitments, will indeed feel assured of a growing amount of business in hand. It may therefore be expected that a rise in their backlogs will induce producers working to order to step up their buying of materials as input requirements increase with higher output and sales rates ahead.

It is necessary to distinguish between this "backlog effect" proper and the "supply conditions effect" discussed previously. The former refers to inventory investment by manufacturers working to order; the latter to inventory investment by those who buy from such manufacturers (including, of course, some manufacturers who fall into the same class, inasmuch as they purchase materials from one another). The hypothesis that inventory investment is a positive function of the rate of change in backlogs is really an extension of the hypothesis that inventory investment is a positive function of the rate of change in sales. This becomes clear when the backlog is conceived as representing future sales. The sales-to-inventory relationship, however, may be rather loose for manufacturers who receive orders in advance of production, precisely because of the particular importance here of the backlog-to-inventory relationship. On the other hand, the proposition that inventory investment depends on supply conditions as viewed by the buyer is clearly quite different in nature from an accelerator-type approach, whether this implies the central role of sales changes or emphasizes backlog changes.

In regressions based on highly aggregative data, e.g., for all manufacturing or manufacturing and trade, the presence of a substantial reaction of inventory investment to changes in unfilled orders can reflect either the backlog effect, the supply conditions effect, or—most likely—some combination of both. The two effects work in the same direction, since the unfilled sales orders of the suppliers are, of course, the outstanding purchase orders of their customers, and the aggregative figures reflect actions of suppliers and customers alike.

Disaggregation can help to clarify the situation. For example, when inventory investment of the primary metals producers is regressed on the change in backlogs for primary metals products, it is the backlog effect that is directly represented. On the other hand, when inventory investment by merchants is regressed on the change in backlogs held by the manufacturers from whom the merchants buy, it is the supply conditions effect that is directly aimed at. It must be realized, however, that this approach is unlikely to reduce the difficulty altogether. This is true not only because little is known about orders, sales, and inventories by vertical stages of production; even with more and better data, a formidable problem would remain because inventory and backlog changes for buyers and sellers (i.e., at the adjoining vertical production stages) appear to be highly intercorrelated.[15]

Goods in Process and Finished Stocks, by Type of Production

Goods-in-process inventories (G) increase when materials are absorbed into the productive process, which occurs at the rate IN_t, and when labor and capital inputs are combined with the materials input, which results in the value-added rate VA_t. The stock G decreases when goods in process are transformed into finished goods, which occurs at the output rate Z_t. Hence,

$$G_t = G_{t-1} + IN_t + VA_t - Z_t. \tag{4}$$

As suggested earlier, the rates of utilization of materials (IN_t) depend on the rates of output presently planned, which, in production to order, can be estimated from new orders received (N_{t-i}). In production to stock, the main determinant will be sales anticipations (S^a), but these may themselves be strongly influenced by the flow of orders received and shipped in the recent past. It seems reasonable to assume that VA_t would also depend to a large extent on the same output and proxy variables.

In production to order, the values of current output and of shipments can be taken to be equal. It follows that $\Delta G_t (= G_t - G_{t-1})$ should de-

[15] Thus, as noted in Chapter 7, the high correlation of the Chicago PAA indexes of backlog diffusion and vendor performance suggests a close association between unfilled orders of the buying and selling companies.

pend positively on new orders received and about to be processed and negatively on $S_t \simeq Z_t$, according to (4) and the preceding considerations.

In production to stock, ΔG_t is presumably a positive function of S^a, which in turn may be approximated by $S_{t-1} = N_{t-1}$. It does not seem likely that a negative net relation will be found between ΔG_t and S_t. In industries working to stock, the time required for production is often short, and it may be less than the unit period of the analysis. Stocks of goods in process are then likely to be small relative to the rates per unit period of output and shipments, that is, their turnover would be high. The observed net effect upon ΔG_t of S_t would in such cases probably be positive, though possibly weak.

Passive inventory investment due to unforeseen changes in demand is presumably a component of net changes in goods-in-process stocks as well as in materials stocks. When $S_t < S_t^a$ this unintended investment is positive, i.e., actual inventory is greater than planned. When $S_t > S_t^a$, unintended investment is negative. Full and prompt adjustments of output could conceivably avert such deviations of actual from planned inventory, but production may not be flexible enough to permit this. Even if it were, such adjustments may be too costly. In these cases, some unplanned inventory changes will be tolerated in preference to unduly large or abrupt output changes.

It is probably quite common for firms to attempt to correct excessive deviations of actual from planned inventories by adjustments in the rate of their purchase orders. Corrective action of this type is clearly restricted to the stage of materials. It appears that the opportunities for stock adjustments in the goods-in-process stage are much more limited. To a large extent (though not completely), the size and composition of goods-in-process inventories are determined by production needs.

To the firm that produces in anticipation of a certain level of market demand, the passive component of inventory investment is most clearly visible in the finished-goods stage: When sales exceed (fall short of) the firm's expectations, the actual stock of finished products (Q) must be correspondingly smaller (greater) than the stock that was expected or planned. At the same time, it is also here that the implications for inventory behavior of the distinction between production to stock and production to order are most evident. In pure production to order, no finished goods are held for sale; here Q consists only of sold products in transit—temporarily stored by the producer-seller or on the way to the buyer. Such stocks exist merely as a by-product of the activity of the firms concerned; the latter do not *plan* investment in finished-goods inventory. For an expanding industry working to order, these stocks are likely to be growing, too, but their movements, apart from such trends, would probably be random or irregular.

In contrast, firms that produce for expected market demand would have, as a rational goal, a *desired* finished-goods inventory consistent with their sales anticipations (although, in any short unit period, the adjustment of actual Q toward the intended level may be only partial). In addition, investment in finished stocks (ΔQ) would here probably contain a passive component reflecting unforeseen changes in sales, as already noted.

To conclude this part of the chapter, analytical considerations suggest strongly that distinctions by type of production (to stock or to order) and by stage of fabrication (materials, goods-in-process, finished goods) are associated with important differences in patterns and determinants of inventory behavior. Different models of inventory investment are therefore appropriate for several different categories of stocks that are defined by this double classification. In much of the recent work on inventory behavior, however, the need for such disaggregation is not fully recognized, and attention focuses directly on aggregate inventories. A summary review of this work follows.

Recent Work on Inventory Investment: A Survey of Findings

Regression Studies of Aggregate Inventories

The apparently large role of inventories in postwar business cycles stimulated much research in this area. The output of this work consists in large part of quarterly regressions based on comprehensive aggregates, and Table 8-2 assembles a large number of such estimates from several published studies.[16]

[16] Because the authors worked independently, the equations often overlap in various ways. Although one could argue that some coordination of the effort would have substantially increased the net value of the work, inferences to this effect based solely on the collected statistical results can be exaggerated: It may be more fruitful to have differing interpretations of similar relationships.

The table indicates a remarkable degree of consensus among the different studies in the selection of the explanatory variables: The most commonly used are levels and changes of sales and unfilled orders. Their treatment varies mainly in that they are taken either with coincident timing or with different leads. Lagged inventory levels and changes are also often included. Most of the studies are based on deflated data but a few use current-dollar series. As a rule the data are seasonally adjusted.

Most of the equations incorporate the flexible-accelerator and buffer-stock concepts developed in earlier literature.[17] Thus, common to the models of Darling and Lovell is the basic assumption that the desired (equilibrium) inventories are a function of sales and that deviations between desired and actual stocks determine, with a lag, the rate of inventory investment. The adjustment of inventories toward the equilibrium level is partial in any period. However, the desired inventory usually depends also on other variables, notably unfilled orders.

The actual stock that is compared with the desired one refers to the time at which the decision regarding inventory investment is made; it is usually taken as of the end of the preceding (or the beginning of the current) period. On this approach, the lagged inventory term will appear with a negative coefficient in the inventory investment equation, but with a positive coefficient in the inventory level equation.[18]

In Table 8-2, the signs of the coefficients of lagged inventory are indeed consistent with this expectation in every case (Table 8-2, part I, column 4, and parts III and IV, column 7). The coefficients are

[17] The main references here are to the work of Metzler (see note 8, above) and Richard M. Goodwin, "Secular and Cyclical Aspects of the Multiplier and Accelerator," in *Income, Employment, and Public Policy: Essays in Honor of Alvin H. Hansen*, New York, 1948.

[18] Suppose that firms, on the average, plan to eliminate in each period a fraction (δ) of the difference between the actual stock (H) and the anticipated desired stock (H_t^a). The latter is a function of anticipated sales (S_t^a), which will as a rule deviate from actual sales by a forecasting error ($S_t^a - S_t$). Then the intended inventory investment would depend on the discrepancy between the desired and the actual stock, and the unintended or passive inventory investment would depend on the error of sales anticipations:

$$\Delta H_t = \delta(H_t^a - H_{t-1}) + \lambda(S_t^a - S_t) + u_t.$$

The coefficient of the previous level of stock (H_{t-1}) should thus be negative ($-\delta$) in the inventory investment equation, and positive ($1 - \delta$) in the corresponding equation for the level of inventory. Cf. Michael C. Lovell, "Factors Determining Manufacturing Inventory Investment," in Joint Economic Committee, *Inventory Fluctuations*, Part I, p. 127; and Lovell, "Determinants of Inventory Investment," in *Models of Income Determination*, Studies in Income and Wealth, Vol. 28, Princeton for NBER, 1964, pp. 179 and 194.

Table 8-2
Regressions of Inventory Levels and Changes on Selected Variables, Total Nonfarm, Manufacturing, and Trade Inventories, Quarterly, 1947–61

Regression [a]	Dependent Variable [b]	Constant Term (1)	Regression Coefficients [b] (2)	(3)	(4)	(5)	(6)	(7)	(8)	R^2 (9)	Stand. Error of Est. (10)	Durbin-Watson Statistic (11)	Period [c] (12)
I. TOTAL NONFARM INVENTORY INVESTMENT													
			S_G^*	ΔU^*	H_{-1}^*	ΔP	ΔS_G^*	U_{-1}^*	ΔH_{-1}^*				
Fromm (F)	ΔH^*	−29.4	.460	.166	−.731					.781	1.912 [d]	1.48	1953–60
			(.137)	(.051)	(.224)								
Klein (K) [e]	ΔH^*	−48.4	.268	.203	−.300	269.3							1948–58
		(13.5)	(.071)	(.047)	(.06)	(75)							
Duesenberry-Eckstein-Fromm (DEF) [f]	ΔH^*	8.5	.295	.771	−.947		−.333	.115	.341	.81	1.74	2.27	1948–57
			(.078)	(.139)	(.267)		(.107)	(.054)	(.115)				
			GNP^*		H_{-1}^*		ΔGNP^*	U^*					
Lovell (L) [g]	ΔH^*	2.5	.328		−.407		−.137	.043		.736			1947–59
		(2.9)	(.040)		(.048)		(.092)	(.007)					
II. MANUFACTURING AND TRADE													
Terleckyj			$(H/S)_{-1/2}^h$	$(N/S)_{-1}$	$(U/S)_{-1/2}^h$	X_n	$\Delta\tilde{P}/\tilde{P}$	$\bar{L}_{-1}$					
T1	$(\Delta H/H)$ [i]	−121.13	−18.48	72.51		−.028	.788	−.026		.91			1948–60
			(3.84)	(9.73)		(.461)	(.111)	(.310)					
T2	$(\Delta H/H)$ [i]	−17.64	−25.26	55.31	2.88					.89	1.12 [k]		1948–60
			(3.07)	(7.18)	(0.74)								
T3	$(\Delta H/H)$ [j]	−14.59	−11.26	30.75	1.88					.78	.87 [k]		1948–60
			(2.33)	(5.52)	(0.57)								

							III. MANUFACTURING						
Smith-Paradiso			S	S_{-1}	S_{-2}	S_{-3}	ΔU_{-1}	H_{-2}					
SP1	H	.760			1.811					.96			1948–61
SP2	H	.801	.465	.367	.270	.770				.98			1948–61
SP3	ΔH	.381					.233			.64			1948–61
SP4	ΔH	–.038		.327			.149	–.173		.80			1948–61
Lovell			S^*	ΔS^*	U^*	ΔU^*	$\Delta P/P$	H^*_{-1}					
L1	H^*	3066.	–.167	–.170	.062		–1.685	.570		.993		1.98	1948–55
			(.033)	(.047)	(.008)		(.410)	(.051)					
L2	ΔH^*	–1.47	.122	–.012	.014	–.002		–.165		.53		1.30	1948–55
		(0.62)	(.024)	(.038)	(.005)	(.024)		(.035)					
Darling			S^*_{-1}		U^*_{-1}	ΔU^*_{-1}	ΔH^*_{-1}	H^*_{-1}	T				
D1	ΔH^*	–0.432	.136					–.190		.310	.723		1948–60
			(.030)					(.041)					
D2	ΔH^*	6.297	.040		.035	.055	.383	–.265	.062	.811	.373	2.105	1948–60
			(.020)		(.011)	(.028)	(.086)	(.076)	(.022)				
D3	ΔH^*	6.850	.060		.038	.061	.373	–.313	.067	.955	.145	2.199	1952–58
			(.020)		(.010)	(.018)	(.129)	(.059)	(.019)				
			S_{-1}			ΔU_{-1}		H_{-2}					
D4[l]	ΔH	–0.387	.415			.324		–.212		.945		1.85	1947–58
			(.044)			(.054)		(.022)					
Kareken-Solow			S	ΔS				H_{-1}	i_{-1}				
(K-S)[m]	H	–1.192	.224	–.106				.762	–1.155	.994			1947–60
			(.027)	(.049)				(.048)	(.405)				
							IV. TRADE						
Darling[n]			S^*		CP	i	$\Delta P/P_{+1}$	H^*_{-1}	ΔH^*_{-1}				
D5	ΔH^*	.268	.096		.018	–.279	12.9	–.243	.142	.510	.261		1951–60
			(.026)		(.010)	(.202)	(7.8)	(.065)	(.146)				
D6	ΔH^*	.190	.073		.025		15.4	–.241		.466	.273		1951–60
			(.016)		(.009)		(7.6)	(.065)					

Notes to Table 8-2

[a] All regression equations, except the six identified in notes e, f, g, m, n, and o, are from the following articles in Joint Economic Committee, *Inventory Fluctuations and Economic Stabilization*, 87th Cong., 1st sess., 1961:

"Analysis of Business Inventory Movements in the Postwar Period," prepared under the general direction of Louis J. Paradiso (Part I by Mabel A. Smith), *ibid.*, Part I, p. 158, Table 2.

Michael C. Lovell, "Factors Determining Manufacturing Inventory Investment," *ibid.*, Part II, pp. 129–30, 143 (Table I), and 145 (Table III).

Paul G. Darling, "Inventory Fluctuations and Economic Instability: An Analysis Based on the Postwar Economy," *ibid.*, Part III, pp. 27 (Table 3) and 37 (Table 5).

Nestor E. Terleckyj assisted by Alfred Tella, "Measures of Inventory Conditions," *ibid.*, Part II, pp. 189–90.

Gary Fromm, "Inventories, Business Cycles, and Economic Stabilization," *ibid.*, Part IV, p. 71.

[b] Wherever available, standard errors are given beneath regression coefficients. Symbols for variables are as follows:

Time subscripts: −1 and −2 indicate leads of one or two quarters ($t-1$, $t-2$). Variables that refer to the current quarter t (timing simultaneous with that of the dependent variable) carry no time subscripts. An asterisk identifies deflated variable (price deflators, 1954 = 100, are used in most cases).

H = inventories at end of quarter.
Δ = change (first difference) in the given variable; e.g.,
ΔH = change in inventories during quarter, $H_t - H_{t-1}$.
S = sales during quarter.
U = unfilled orders.
GNP = GNP in billions of 1954 dollars.
ΔP = change in the implicit GNP deflator, 1954 = 100.
$\Delta\tilde{P}/\tilde{P}$ = percentage change in the index of industrial wholesale prices, $(\tilde{P}_t - \tilde{P}_{t-1})/\tilde{P}_t$.
$\Delta H/H$ = percentage change of manufacturing and trade inventories less inventory valuation adjustments.
H/S = ratio of inventories to sales.
N/S = ratio of new orders to sales. (In trade, new orders are assumed to equal sales.)
U/S = ratio of unfilled orders to sales.
X_H = percentage change in inventories attributable to changing mix (composition of business).
S_G = final sales of goods (GNP accounts in 1954 dollars).
$\bar{i}$ = interest rate on four-to-six-month prime commercial paper; average for the first quarter of the six-month unit period.
i = bank rate of interest on short-term business loans, average for nineteen large cities (per cent).
CP = percentage of capacity output utilized in manufacturing (McGraw-Hill).
$\Delta P/P(\,)$ = percentage change in the wholesale price index during quarter $t(0)$ or $t+1(+1)$.
T = time trend.

[c] Identifies the first and last year for which data were used. These years are not necessarily completely covered.

[d] Billions of current dollars at annual rates.

[e] See Lawrence R. Klein, "A Postwar Quarterly Model: Description and Applica-

tions," *Models of Income Determination*, Studies in Income and Wealth, Vol. 28, Princeton for NBER, 1964, e.g., (6), p. 16. This equation is part of a large interdependent system. The method of estimation is limited information, maximum likelihood. The correlation coefficient $\bar{R} = .99$ (stock form); it is computed as

$$\sqrt{1 - \frac{\Sigma Z^2}{T - m} \frac{T - 1}{\Sigma x^2}},$$

where Z is the residual, x is the dependent variable, and m is the number of parameters in the equation. Unlike elsewhere in this section, farm inventories are not excluded here.

[f] See James S. Duesenberry, Otto Eckstein, and Gary Fromm, "A Simulation of the United States Economy in Recession," *Econometrica*, October 1960, p. 798.

[g] See Michael C. Lovell, "Determinants of Inventory Investment," in *Models of Income Determination* (see note e, above), equation (2.15), p. 186.

[h] Ratio at the beginning of the period.

[i] Six-month changes.

[j] Three-month changes.

[k] Percentage points. Unbiased estimates.

[l] See Paul G. Darling, "Manufacturers' Inventory Investment, 1947–1958," *American Economic Review*, December 1959, pp. 950–63.

[m] See John Kareken and Robert M. Solow, "Lags in Fiscal and Monetary Policy," in Commission on Money and Credit, *Stabilization Policies*, Research Study One, Part I, Englewood Cliffs, N.J., 1963, equation (7), p. 43.

[n] See Paul G. Darling and Michael C. Lovell, "Factors Influencing Investment in Inventories," in Duesenberry et al., eds., *Brookings Quarterly Econometric Model of the United States*, equations (4.12) and (4.13), p. 151.

generally rather small in absolute terms, varying from −.165 to −.407 in the investment equations.[19]

Reaction coefficients of 0.2 to 0.4 suggest that from about one-fifth to two-fifths of the discrepancy between desired and actual inventory would be eliminated each quarter if no further change occurred in sales (or, generally, in the determinants of the desired stocks). This raises a doubt and a question: Why should the adjustments of inventories to the desired levels be so painfully slow, resulting in such inordinately large unintended stocks?[20] It should be remembered that

[19] The two apparent exceptions are in equations F and DEF, where the estimated coefficients of lagged inventory are as large as −.731 and −.947, respectively. However, the flows are measured at annual rates here, not as absolute quarterly changes as in the other regressions; hence, these figures should be divided by 4 for comparability, which results in estimates of −.185 and −.195, respectively. Cf. James S. Duesenberry, Otto Eckstein, and Gary Fromm, "A Simulation of the United States Economy in Recession," *Econometrica*, October 1960, p. 796.

[20] See the calculated "surplus inventory" series in Lovell, "Determinants," pp. 187–88, for equation L in Part I of Table 8-2. Here, the coefficient of H^*_{t-1} is on the high side of the estimates (0.407), but the surplus inventory figures are still relatively very large (most often absolutely greater than the corresponding values of actual inventory investment).

the estimates refer to aggregates that include not only the typically lagging finished-goods inventories of firms selling from stock but also purchased materials and goods-in-process stocks, which should be geared much more closely to sales and production. These results, then, seem to me rather suspect: They could be underestimating the speed of adjustment because of a misspecification of the determinants of the "desired" inventory.

The principal factors used as such determinants are sales and unfilled orders. They are sometimes assigned leads relative to the dependent inventory variable but are often taken as simultaneous with the latter (compare equations D1–D3 with equations L1–L2). But actual sales are not yet known at the time when the firm decides upon the level of its output and any desired inventory change, except in production to order (where the known sales should be represented not by the current shipments, but by advance orders received). Hence, in principle, anticipated or ex-ante sales (S_t^a) should be used as the main determinant of the desired inventory, not the actual or ex-post sales (S_t). In short, unless sales are made in advance of production, they must be predicted. Usually, forecasts of sales will contain errors, and these are likely to result in some unintended or passive inventory investment.

If the forecasts were unbiased and their errors were random, a rationale would exist for the use of S_t as a surrogate measure of S_t^a for analytical purposes; and in this case the "passive" inventory component could itself be treated as random and incorporated in the residuals of the inventory equation.[21] But there is no firm theoretical or empirical basis for this approach. According to Nurkse, "if the cyclical variation in aggregate demand is not treated as a random perturbation, the passive component of inventory investment cannot be either." [22] Observations on sales anticipations are scanty, and studies based on them are on the whole rather inconclusive. However, even

[21] This approach is implicit in the inventory equation of the early aggregate model by Lawrence R. Klein (see his *Economic Fluctuations in the United States, 1921–41*, New York, 1950). Its logic and implications have been worked out by Edwin S. Mills in "Expectations, Uncertainty, and Inventory Fluctuations," *Review of Economic Studies*, No. 1, 1954–55, pp. 15–23, and in "The Theory of Inventory Decisions," *Econometrica*, April 1957.

[22] "Cyclical Pattern," p. 396. Nurkse recognizes that random shifts in demand from one product to another may make the passive inventory investment a random variable for individual firms or industries. But such changes "will be in opposite directions, tending in the aggregate to cancel out. In dealing with total inventory investment, the unintended change that remains cannot be due to such random intercommodity shifts, but can only stem from the expansion and contraction of demand in the aggregate. . . ."

the most favorable of the results obtained do not show anticipations to be so unbiased and efficient as to justify any confident use of realized sales as a proxy for expected sales.[23]

Under certain assumptions, the effect of errors in sales anticipations could be inferred approximately from the coefficient of the change in sales (ΔS_t) in the inventory equation.[24] In the simple case of naive expectations, $S_t^a = S_{t-1}$, that coefficient would measure directly the fraction of the forecasting error that results in inventory change.[25] More generally, if systematic expectational errors exist and give rise to passive inventory investment, then ΔS_t is likely to have a significant negative effect in inventory equations.

In Table 8-2, change-of-sales variables are included in five regressions; their coefficients are all negative but two are not significant (see in Part I, DEF and L; in Part III, L1, L2, and K-S). It must be remembered that these estimates refer to total inventories, aggregated across categories with different behavioral characteristics. The hypothesized relation between sales anticipation errors and buffer stocks seems primarily and directly applicable to finished-goods inventories; it can be extended by analogy and implication to goods-in-process and purchased materials, but there it may well be much less pertinent. More important, the hypothesis is definitely limited to industries working to stock, in anticipation of market demand.

The measured effects of the backlog factor are in general strong, ranking with those of sales. For example, according to the current-

[23] The new quarterly OBE series on manufacturers' sales expectations apparently work better than some of the old (and notoriously weak) anticipations data. However, for some industries, these series mainly reflect information conveyed by orders received and unfilled. Generally, their effective forecast span is short, and their contribution to estimated models of inventory generation is neither large nor well established. (See the last section of Chapter 2; also, M. C. Lovell, "Sales Anticipations, Planned Inventory Investment, and Realizations," and comments by M. Hastay and R. Eisner in *Determinants of Investment Behavior*, Universities-National Bureau Conference 18, New York, NBER, 1967.) I believe the conclusion I draw in the foregoing text is a fair inference from the materials presented in Albert A. Hirsch and Michael C. Lovell, *Sales Anticipations and Inventory Behavior*, New York, 1961.

[24] This will be so, for example, if the anticipated sales change represents a fraction of the actual change and the effects of current output and price adjustments are separately estimated or assumed to be negligible. See Lovell, "Determinants," pp. 203–204.

[25] Suppose that $H_t^a = \alpha + \beta S_t^a$. By substitution into the equation shown in note 18, above, one gets

$$\Delta H_t = \delta\alpha + (\delta\beta + \lambda)S_t^a - \lambda S_t - \delta H_{t-1} + u_t.$$

If $S_t^a = S_{t-1}$, this is equivalent to

$$\Delta H_t = \delta\alpha + \delta\beta S_{t-1} - \lambda(S_t - S_{t-1}) - \delta H_{t-1} + u_t.$$

If $S_t^a = S_t + v_t$, where v_t is random (as in the studies referred to in note 21), then

$$\Delta H_t = \delta\alpha + \delta\beta S_t - \delta H_{t-1} + (\delta\beta + \lambda)v_t + u_t.$$

dollar estimates SP3 and SP4, the change in manufacturers' unfilled orders alone accounts for 64 per cent of the variance in manufacturers' inventory investment in 1948–61; the addition of the prior sales change and inventory level raises this proportion to 80 per cent. In another study using deflated variables, a regression of inventory investment on prior sales change and inventory level yielded an R^2 of only .310, and the addition of the unfilled orders variables U^* and ΔU^*_{t-1}, plus a ratchet term and trend factor, raised R^2 to .811 (equations D1 and D2). The role of unfilled orders is also important in the regressions for total or nonfarm inventory investment and for manufacturing and trade inventories combined (all the equations in Part I of Table 8-2 and, also, equations T2 and T3).[26]

The aggregative backlog-inventory relationship, although highly significant statistically, does not lend itself to a straightforward analytical interpretation. Since unfilled orders of sellers are also outstanding orders of buyers, their rise may stimulate inventory investment of buyers as well as sellers in two different ways. Aggregation over the stages of fabrication provides still another source of difficulty. An increase in unfilled orders is likely to stimulate buying of *materials* by those who are to fill the orders, but it will hardly be associated with an increase in the finished stocks of these producers. On the contrary, where backlogs accumulate so that production may be order-oriented, the need for finished inventory is reduced.

Other variables received considerably less attention and yielded results that seem partly negative but should probably be regarded rather as inconclusive. Lovell found no support for the hypothesis that actual price increases, by creating expectations of price rises, stimulate inventory investment; actually, the coefficient of $\Delta P/P$ in his equation L1 is negative. Darling did obtain positive coefficients for his proxy for price expectations (the proportionate change in the wholesale price index during the *approaching* quarter) in his study of trade inventories (equations D5 and D6).[27] One possible explanation for the negative results in the manufacturing equations is that the effect of the

[26] In the T equations, unfilled orders are used in the form of a ratio to sales. Also included is the ratio of new orders to sales, which is highly correlated with the *change* in unfilled orders. Terleckyj assumes that unfilled orders in trade are nil. His results raise a difficulty concerning the influence of sales (see Lovell, "Determinants," p. 185).

[27] Terleckyj also reports a significant positive coefficient for the concurrent relative change in the industrial price index, but not for the prior change. The use of undeflated data in his study might be an appreciable drawback in this context.

price change could not be separated from that of the change in unfilled orders. However, Klein reports significant positive associations between aggregate inventory investment and changes in both the GNP price deflator and unfilled orders (the price variable being taken without and the backlog variable with a lead; see equation K).

The Kareken-Solow equation based on undeflated data for manufacturing includes the interest rate on short-term bank loans to business with a significant coefficient that has the expected negative sign and denotes a small (−0.4) elasticity at the point of the means. The evidence on the effects of interest rates and liquidity factors assembled by McGouldrick is mixed and not encouraging.[28] In contrast to these studies, more promising indications of the role of financial variables in inventory determination are reported by Ta-Chung Liu[29] and Paul W. Kuznets.[30]

Major-Industry and Stage-of-Fabrication Estimates

Disaggregation by industry and stage of fabrication is not a frequent feature of regression studies of inventory behavior. Furthermore, disaggregation has for the most part been used in a very limited sense, with the same or very similar models being applied to the different sectors or categories of stocks.

Table 8-3 shows some further results of Lovell's 1961 study.[31] These

[28] See Paul F. McGouldrick, "The Impact of Credit Cost and Availability on Inventory Investment," in Joint Economic Committee, *Inventory Fluctuations*, Part II, pp. 89–117.

[29] "An Exploratory Quarterly Econometric Model of Effective Demand in the Postwar U.S. Economy," *Econometrica*, July 1963, pp. 301–48. Liu uses a real-interest variable, defined as the difference between the average rate on prime commercial paper (4–6 months) and the lagged rate of change in the GNP price deflator, both in per cent per year. Its coefficient is about −0.3, with a standard error half as large. Interestingly, Liu's equation also includes, among others, money and time deposits held by nonfarm nonfinancial business (in constant dollars). This variable has a positive coefficient, which, however, is small relative to its standard error, according to simple least squares (the two-stage estimate is more significant).

[30] "Financial Determinants of Manufacturing Inventory Behavior: A Quarterly Study Based on United States Estimates, 1947–1961," *Yale Economic Essays*, Fall 1964, pp. 331–69. The equation that presents the financial variables in the best light reads:

$$(H_t)_{est} = \underset{}{-953.3} + \underset{(.018)}{.088S_t} + \underset{(.010)}{.042U_t} + \underset{(0.253)}{1.071IF_{t-1}} + \underset{(.028)}{.114XF_{t-1}} - \underset{(7.2)}{15.6i_{t-1}} + \underset{(.049)}{.737H_{t-1}},$$

where the data are for all manufacturers, in constant (1954) dollars. IF and XF denote internal and external finance, respectively, and i is the average interest rate for short-term business loans. Each of the three financial variables is here transformed according to a moving average formula with triangular weights that implies rather extended (seven-quarter) adjustment periods. When these variables are entered with simple one-period lags (in an equation which contains the same nonfinancial variables, including H_{t-1}), the coefficients of i_{t-1} and IF_{t-1} are apparently not significant. On the other hand, the other variables require no transformation, and their effectiveness seems to be relatively independent of the different specifications of the financial factors (*ibid.*, Table 1, p. 352).

[31] In *Inventory Fluctuations*, Part II. This is also the source of equations L1 and L2 in Table 8-2.

Table 8-3

Regressions of Inventory Levels and Changes on Selected Variables, Total Inventories, Purchased Materials and Goods in Process, and Finished-Goods Inventories, All Manufacturing and Major-Industry Groups, 1948–55 and 1948–60

Industry	Dependent Variable	Constant Term	Regression Coefficients					R^2	Durbin-Watson Statistic
			PURCHASED MATERIALS AND GOODS IN PROCESS						
			Z^*	ΔZ^*	U^*	$\Delta P/P$	$(M+G)^*_{-1}$		
1. All mfg.	$(M+G)^*$	4004	.062	−.100	.061	−.320	.542	.993	2.27
			(.016)	(.030)	(.005)	(.206)	(.046)		
2. Durables	$(M+G)^*$	1412	.053	−.080	.038	.038	.637	.994	1.82
			(.019)	(.030)	(.004)	(.173)	(.034)		
3. Nondurables	$(M+G)^*$	−356	.023	−.037	.221	.148	.903	.970	2.02
			(.021)	(.056)	(.051)	(.121)	(.067)		
			FINISHED-GOODS INVENTORIES						
			S^*	ΔS^*			Q^*_{-1}		
4. All mfg.	Q^*	−258	.042	.132			.848	.958	1.39
			(.020)	(.042)			(.065)		
5. Durables	Q^*	−326	.055	.097			.817	.966	1.33
			(.014)	(.028)			(.052)		
6. Nondurables	Q^*	419	.006	.170			.935	.947	1.57
			(.029)	(.068)			(.086)		

		TOTAL INVENTORIES (LEVEL OR CHANGES)								
			S^*	ΔS^*	U^*	ΔU^*	$\Delta P/P$	H^*_{-1}		
7. Durables	H^*	1032.	.126	.104	.037		–.499	.676	.991	1.46
			(.037)	(.054)	(.006)		(.331)	(.045)		
8. Durables	ΔH^*	–1.55	.127	–.002	.009	.047		–.115	.57	1.23
		(0.55)	(.033)	(.044)	(.005)	(.021)		(.033)		
9. Nondurables	H^*	–661.	.036	.171	.329		–.618	.926	.981	2.23
			(.038)	(.075)	(.083)		(.185)	(.065)		
10. Nondurables	ΔH^*	–0.508	.043	–.029	.254	–.356		–.082	.66	1.93
		(0.409)	(.016)	(.033)	(.046)	(.058)		(.039)		
11. Primary metals	H^*	–172.8	.063	.043	.018		–.036	.945	.939	1.72
			(.031)	(.032)	(.012)		(.035)	(.053)		
12. Machinery	H^*	751.9	.035	.070	.059		.029	.701	.991	1.49
			(.039)	(.065)	(.007)		(.067)	(.043)		
13. Transport. equip.	H^*	266.0	.083	.031	.032		.006	.684	.990	1.13
			(.032)	(.046)	(.005)		(.084)	(.054)		
14. Stone, clay, and glass	H^*	27.4	.108	.234	[a]		.002	.733	.978	1.29
			(.020)	(.050)			(.020)	(.051)		
15. Other durables	H^*	32.8	.122	.135	[a]		[a]	.806	.960	0.92
			(.030)	(.048)				(.050)		

Note: See Table 8-2, note b, for explanation of all symbols except the following:

M = purchased material inventories.

G = goods-in-process inventories.

Q = finished-goods inventories.

$Z = S + \Delta Q$ = value of output estimated by adding change in finished-goods inventory to sales.

Source: Michael C. Lovell, "Factors Determining Manufacturing Inventory Investment," in Joint Economic Committee, *Inventory Fluctuations and Economic Stabilization,* 87th Cong., 1st sess., 1961, Part II. Entries on lines 1–3 are from Table I, p. 143; lines 4–6, from Table II, p. 144; and lines 7, 9, and 11–15, from Table III, p. 145. All these regressions are based on deflated, seasonally adjusted, quarterly series for 1948–55. Entries on lines 8 and 10 are from equations given in *ibid.*, pp. 129–30; they refer to quarterly deflated and deseasonalized data for 1948–60.

[a] Lack of data is cited as the reason for absence of estimates in these cells.

regressions use largely simultaneous relationships between constant-dollar series. Only one of the explanatory variables is taken with a lead: the inventory level as of the end of the previous quarter, H^*_{t-1}. However, no account is taken of the possible feedback effects of inventory investment on sales, unfilled orders, etc., that could impose a simultaneous equation bias on the estimates.

One model, based on the flexible or partial-adjustment version of the acceleration principle, is adopted for both the purchased-materials and goods-in-process inventories (first three lines). The desired level of the combined inventory for these two stages is assumed to be a linear function of the level of output, the change in output, unfilled orders, and the relative change in the wholesale price index. Realized inventory investment, $\Delta(M + G)^*_t$, is viewed as a fraction, δ, of the difference between the desired and the available stock. Since the dependent variable is the *level* of inventory, its previous value, $(M + G)^*_{t-1}$, has the coefficient $(1 - \delta)$.

The sign of the coefficient of the change in output ΔZ^*_t, is not clearly prespecified. "When output is increasing, orders may be placed with suppliers in an attempt to build up stocks, but considerable delays may be involved in obtaining delivery."[32] On this reasoning, the effect of ΔZ^*_t would be positive if the attempt succeeded. Negative estimated coefficients would then be attributed to long delivery lags for materials. But the evidence reviewed earlier in this chapter suggests that the delivery lags for materials are on the whole rather short. A different explanation of the negative effect of ΔZ^*_t is that this term, being well correlated with ΔS^*_t, reflects the influence of sales anticipation errors in production to stock: After all, passive or unintended changes due to such errors can occur in purchased-materials and goods-in-process inventories as well as in finished-goods stocks. Of course, unexpected delivery delays may here and there also contribute to the observed results.

The model appears to work poorly for the nondurable goods sector, where the estimates are unsatisfactory or implausible. The coefficients of Z^*, ΔZ^*, and $\Delta P/P$ are all small relative to their standard errors, and the reaction coefficient δ, computed as 1 minus the coefficient of lagged inventory, is very small indeed (0.097). Of the causal variables,

[32] *Ibid.*, p. 140.

only unfilled orders, which in this sector are assumed to be nil for most industries and of modest size for a few (according to the statistics used), have a significantly large positive coefficient (Table 8-3, third line). The results for all manufacturing and the durable goods sector are considerably better, since Z^* and ΔZ^*, as well as U^*, show significant effects, while the estimates for δ are much larger and more reasonable (0.458 and 0.363, respectively). However, the evidence on the influence of price changes $\Delta P/P$ is again negative.

In the finished-goods inventory equations, a simple form of the "buffer-stock motive" is adopted and neither U^* nor $\Delta P/P$ is included. Deflated sales, not output, are now used. The influence of S_t^* is positive and significant for all manufacturing and the durable goods industries, but it is not significant for the nondurables. The coefficients of ΔS_t^* are large relative to their standard errors in each case, but they are positive. If these coefficients were to represent the effects of sales anticipation errors that result in passive or unintended inventory changes, their signs ought to be negative. On Lovell's more complex interpretation, however, these estimates must be "unscrambled" to reveal the implicit "anticipation coefficient," ρ.[33]

One would expect the adjustments of finished-goods inventories to be slower than those of the materials and goods-in-process inventories. The coefficients of Q_{t-1}^* are much higher than those of $(M+G)_{t-1}^*$ in Table 8-3, which is, in terms of the model applied here, consistent with this expectation. But the implied reaction coefficients of 0.152 for all manufacturing, 0.183 for the durables, and 0.065 for the nondurables seem uncomfortably low. The large coefficients of Q_{t-1}^* reflect the high autocorrelations of the smooth series on aggregate finished-goods stocks, and probably also reflect the limitation of these equations to two causal variables (S^* and ΔS^*) only; it is not at all clear that they can be safely used to infer extremely low reaction coefficients, i.e., extremely slow inventory adjustments.

[33] Defining $S_t'' = \rho S_{t-1} + (1-\rho)S_t$ implies that $\rho = 1$ for naive or static expectations ($S_t'' = S_{t-1}$) and $\rho = 0$ for unbiased expectations ($S_t'' = S_t$). On this definition, the coefficient of ΔS_t equals $(\delta\beta + \lambda)\rho$ (see notes 18 and 25, above, on the meaning of δ, β, and λ). The model does not provide sufficient information to permit unconstrained simultaneous estimation of both λ and ρ. If one assumes that $\lambda = 1$ (complete inflexibility of production plans), ρ varies from 0.092 for the durables to 0.168 for the nondurables. The implication would be that manufacturers' sales forecasts are rather good, particularly in the durable goods sector. If moderately large output adjustments were assumed, the estimates of ρ would be larger, but still not very high (given $\lambda = 0.5$, for example, ρ for all manufacturing would be 0.243, instead of 0.126, obtained when $\lambda = 1$).

The equations for total inventories (Table 8-3) use a combination of the stage-of-fabrication models. It is interesting that the coefficients of both S_t^* and ΔS_t^* are not significant for machinery, an industry with a large proportion of output produced to order. On the other hand, the coefficients of both S_t^* and ΔS_t^* are highly significant for two industry groups in which production to stock is very definitely the rule: stone, clay, and glass products and "other durables." However, the coefficients of ΔS_t are here again positive.[34]

The coefficients of unfilled orders are all positive and are generally large relative to their standard errors. It may be worth noting that the largest t ratios for U_t^* are in the equations for machinery and transportation equipment, while the lowest recorded ratio is in the equation for primary metals. In the inventory-investment regressions, ΔU_t^*, which is included along with U_t^*, appears to have a positive effect in durables but a negative effect in nondurables. These results suggest that the influence of unfilled orders on inventory behavior is greater in industries where production to order is important, but the evidence is far from conclusive.

The assumption that unfilled orders affect the inventories of materials and goods in process, but not those of finished goods, receives some support from the estimates in Table 8-3. The coefficients of U_t^* in the durable goods regression for $(M + G)_t^*$ and for H_t^* are almost identical.

The evidence on the influence of price changes is entirely negative for the total-inventory equations, as it was for the materials and goods-in-process equations. The coefficients of $\Delta P/P$ have minus signs as often as plus signs but are in any event typically quite small when compared with their standard errors.

In their critique of Lovell's two models (one for materials and goods-in-process inventories, the other for finished-goods inventories), Eisner and Strotz conclude that "we cannot really distinguish between them (identify them) on the basis of the statistical results." [35] They are

[34] The coefficient of ΔS_t^* is also positive and fairly significant in the total-inventory regression for the durables, but it is negative and not significant in the inventory investment regression. In the total-inventory equation for nondurables, S_t^* is not effective, but ΔS_t^* is; in the corresponding inventory-investment equation, the opposite applies. These estimates for the comprehensive industry groups, then, seem rather ambiguous, as if they were adversely affected by aggregation (in addition to any basic specification errors).

[35] R. Eisner and R. H. Strotz, "Determinants of Business Investment," in Commission on Money and Credit, *Impacts of Monetary Policy*, Englewood Cliffs, N.J., 1963, p. 220.

not persuaded that inventories should be disaggregated by stage of fabrication and state their preference to "disaggregate by motive" (*ibid.*, p. 106). But motivations, here as elsewhere, must be analyzed within the context of the relevant technological and institutional constraints.[36] If my observations are correct, Lovell's results suffer from insufficient rather than from excessive disaggregation (as well as from some errors of specification). It is important for the analysis of inventory behavior to distinguish between production to stock and production to order, and among the stages of fabrication, and to combine these distinctions.

Disaggregation by Type of Production

Thomas J. Courchene has recently made a very interesting examination of several hypotheses relating to the central proposition that inventory behavior differs significantly between industries producing largely to stock and industries producing largely to order, depending at the same time also on the stage of fabrication at which the stocks are held.[37] Courchene computed inventory investment regressions for ten divisions of Canadian manufacturing that are broadly similar to the U.S. data for the "market categories." Particularly interesting, and emphasized, are his estimates for two sectors in which inventory policies are governed by demand rather than supply conditions: (1) heavy transportation equipment (HTE), where production is almost exclusively to order; and (2) semidurable consumer goods (SDCG), where production to stock definitely predominates.[38]

Courchene's main results for these two sectors are reproduced in Table 8-4. Application to extremes should bring out the hypothesized

[36] The motives for investment and their implications certainly form an important subject to be studied with the aid of economic theory, whether it is investment in inventories or in other capital goods such as structures and equipment; but so are the above-noted "constraints." Now, in the case of inventories, these underlying conditions are quite different for, say, investment in materials (which are inputs into the production process) and finished goods (which, for the investing firm, are the outputs). Such distinctions, therefore, may be as important as those by motives, even from a purely theoretical point of view.

[37] Courchene, "Inventory Behaviour and the Stock-Order Distinction: An Analysis by Industry and Stage of Fabrication with Empirical Application to the Canadian Manufacturing Sector," *Canadian Journal of Economics and Political Science*, August 1967, pp. 325–57.

[38] Applying the criterion of the stock-backlog ratios Q/U (as discussed in Chapter 2 above), Courchene presents a "ranking of sectors along [a] stock-order spectrum." Classified as producing primarily to order are heavy transportation, other capital goods, and construction goods, while intermediate goods and supplies, motor vehicles, "largely export producing," and semidurable and perishable consumer goods, are found to represent primarily manufacture to stock. The durable consumer goods sector is treated as mixed.

Table
Regressions for Inventory Investment by Stage of Fabrication,

			Regression					
			New and Unfilled Orders			Shipments	
Stage of Fabrication[a]	Dep. Var.	Constant Term (1)	U_t; N_{t-1} (2)	N_t (3)	U_{t-2}; U_{t-1} (4)	S_t (5)	S_t; $(S_t - N_{t-1})$ (6)
						HEAVY TRANSPORTATION	
1. PM	ΔM_t	2.765 (2.91)	$0.037\Delta U_t$ (3.90)		$0.038U_{t-1}$ (3.52)		
2. GIP	ΔG_t	5.363 (2.15)	$0.241N_{t-1}$ (7.83)	0.142 (5.41)	$0.295U_{t-2}$ (8.19)	−0.307 (3.75)	
3. FG	ΔQ_t	0.170 (0.65)				−0.0075 (0.73)	$0.0074\Delta S_t$ (0.87)
4. All	ΔH_t	10.62 (3.03)	$0.266N_{t-1}$ (6.17)	0.151 (4.35)	$0.317U_{t-2}$ (5.97)	−0.280 (2.59)	
						SEMIDURABLE CONSUMER	
5. PM	ΔM_t	−1.266 (0.80)		0.165 (3.98)	$0.159U_{t-1}$ (2.84)		$-0.193(S_t - N_t)$ (4.06)
6. GIP	ΔG_t	0.401 (0.78)			$0.066U_{t-1}$ (3.81)	0.063 (4.39)	$-0.047\Delta S_t$ (3.03)
7. FG	ΔQ_t	0.202 (0.33)				0.130 (3.66)	$-0.176\Delta S_t$ (4.18)
8. All	ΔH_t	−2.291 (0.86)		0.264 (4.41)	$0.217U_{t-1}$ (2.36)		$-0.381(S_t - N_{t-1})$ (5.18)

Note: For explanation of symbols see Table 8-2, note b, and Table 8-3, Note. The series are seasonally adjusted and undeflated and are for I-1955–IV-1962. Most of the data are from the Dominion Bureau of Statistics, *Inventories Shipments and Orders in Manufacturing Industries* ("Economic Use Classification" of Canadian industries). Monthly observations are converted to quarterly observations by summing for the flows and by using the values for the last month of the quarter for the stocks. Figures in parentheses below the coefficients are t values.

Source: Thomas J. Courchene, "Inventory Behaviour and the Stock-Order Distinc-

8-4
Two Sectors of Canadian Manufacturing, Quarterly, 1955–62

Coefficients: Inventories: Lagged, Same Stage (7)	Inventories: Other (8)	Inventories: Other (9)	Interest Rate[b] (10)	Time Trend (11)	R (12)	Durbin-Watson Statistic (13)
EQUIPMENT (HTE)						
$-0.181M_{t-1}$	$0.609\Delta M_{t-1}$	$-0.078G_t$	−0.239		.70	2.32
(2.31)	(3.49)	(2.95)	(1.99)			
$-0.549G_{t-1}$			−2.434	0.278	.91	2.39
(6.55)			(4.50)	(5.26)		
$-0.061Q_{t-1}$	$-0.203\Delta Q_{t-1}$	$.002\Delta G_t$		0.003	.40[c]	1.80
(0.37)	(1.02)	(.017)		(0.68)		
$-0.601H_{t-1}$			−2.387	0.210	.84	1.70
(5.04)			(3.34)	(3.14)		
GOODS (SDCG)						
$-0.392M_{t-1}$					.67	1.73
(3.40)						
$-0.244G_{t-1}$	$-0.138M_{t-1}$				.76	2.24
(2.98)	(3.69)					
$-0.379Q_{t-1}$	$1.480\Delta G_t$	$0.345\Delta M_t$			.78	2.29
(4.50)	(3.52)	(2.70)				
$-0.275H_{t-1}$					.75	1.50
(3.42)						

tion: An Analysis by Industry and Stage of Fabrication with Empirical Application to the Canadian Manufacturing Sector," *Canadian Journal of Economics and Political Science*, August 1967, pp. 325–57.

[a] PM = purchased materials; GIP = goods in process; FG = finished-goods inventory; All = total inventory (all stages combined).

[b] Corporate bond rate, taken with a one-quarter lag.

[c] Refers to the regression which includes, in addition to the terms listed in this table, ΔM_t, whose coefficient is not significant (−0.012 with a t ratio of 0.19).

differences in inventory behavior most forcefully, but comparisons between other sectors in which either type of production prevails should also show such differences, although in a more attenuated form. The evidence confirms this expectation in large part. Limitations of the available data, however, seriously impede the analysis and also its evaluation.[39]

The basic approach is once more guided by the familiar flexible-accelerator hypothesis. Intended inventory investment is a fraction of the difference between the desired and the available stock. A negative coefficient of the lagged inventory term is therefore expected. Its absolute magnitude is viewed as an estimate of the above fraction. These coefficients are shown in column 7 of Table 8-4; they are all negative and significant, except for the coefficient of Q_{t-1} in the finished-goods equation for the HTE sector, which is not significant.

The main differences in inventory behavior between production to stock and production to order derive from differences in (1) the roles of new orders and shipments as determinants of planned output and inventories; (2) the significance of passive or unintended inventory investment; and (3) the nature and function of finished-goods inventories.

1. In the HTE sector, representing manufacture to order, previous values of unfilled orders (U_{t-2}) are important factors in the purchased-materials and goods-in-process equations (Table 8-4). Large backlogs indicate high levels of future output, hence greater materials requirements for production. It is also possible that, when backlogs of order accumulate, buying of materials would be accelerated because of expected delays on the suppliers' deliveries.[40] Goods-in-process stocks tend to be closely related to the role of production, which is here largely determined by the amount of new orders received in the past; but output is made less volatile than new orders because backlogs act as a buffer. Hence ΔG_t depends positively on prior values of new and

[39] The quarterly series used cover only eight years, 1955–62. Corresponding price data are not available, and the series are not deflated. Sales anticipations are not directly measured but are equated to the preceding values of shipments or new orders, thus implying that a naive model of current-level extrapolation adequately represents the expectational process involved. The validity of the concept of materials ownership and the need for data on orders placed are recognized, but the manufacturing statistics for Canada (like those for the United States) refer only to orders received and unfilled, not to orders placed and outstanding.

[40] Here it would be more appropriate to use the unfilled orders of the materials suppliers as an indicator, rather than the unfilled orders of the purchasers, but data are available only for the latter.

unfilled orders, with some sizable lags reflecting the time-consuming nature of the production process involved (second line).

Stocks of materials are increased through deliveries on purchase orders and decreased through transformation into stocks of goods in process [see equation (1), above]. The regression for ΔM_t in the first line includes the stock of goods in process, G_t, which has a significant negative coefficient, thus roughly isolating the effect of the rate of this transformation (i.e., of the use of materials as productive inputs, IN_t).

Stocks of goods in process are increased through inflow of materials and decreased through outflow into the finished-goods stocks [equation (4), above]. The rate of this outflow is measured by the rate of output or (in production to order) of shipments. Hence, ΔG_t should be negatively related to S_t, and it is (second line).[41]

In the SDCG sector, representing manufacture to stock, elements of production to order nevertheless exist, as indicated by the presence of unfilled orders which, although relatively small, have significant effects on ΔM_t and ΔG_t (see fifth and sixth lines, column 4). However, the lags are shorter, and the importance of the backlog factor (as indicated by the t ratios) is smaller for the SDCG sector than for the HTE one.

Since the production process is typically short for SDCG, it is not possible here to distinguish between the inflow and outflow factors in the purchased-materials and goods-in-process regressions. The turnover ratios of quarterly shipments to product inventory are high—greater than 1—in this as in other sectors producing primarily to stock. New orders or shipments (the two do not differ much) appear with positive signs in the SDCG equations for ΔM_t and ΔG_t (fifth and sixth lines, columns 3 and 5).

2. Sales anticipations that guide production in industries working to stock inevitably generate errors, and so passive inventory investment due to these errors is a feature of these industries. As an illustration, the coefficients (column 6) of ΔS_t or of $(S_t - N_{t-1})$ are all negative and highly significant for the SDCG sector. Where production is undertaken in response to demand (past orders from customers), rather than

[41] Note that the coefficient of S_t is also negative in the total inventory investment equation for HTE (column 5). This can only be explained in production to order; in production to stock, the effect of S_t is positive (see text below), and it is usually presumed to be so in aggregate inventory analyses. Courchene also reports that for total Canadian manufacturing, the coefficient of S_t in the equation for ΔG_t is insignificant, because of offsetting effects in the two types of production (*ibid.*, pp. 343–44).

in anticipation of demand (future market sales), there is clearly no basis for such an association between forecasting errors and inventory changes. The coefficient of ΔS_t in the finished-goods equation for the HTE sector is therefore not significant, as would be expected (third line). Sales forecast errors may influence purchases of materials by industries producing to order, but it is difficult to isolate this effect in regressions for *net change* in materials stocks (where purchase orders for materials are not separately observed or analyzed).

3. Stocks of finished goods are small in the HTE sector, representing mainly sold output in transit to the buyer. Changes in such stocks should be largely random, due to occasional shipping delays and perhaps cancellations (but the latter are not likely to be very frequent in this late stage of production), although some upward trend could arise here for a growing industry. In fact, the flexible-accelerator hypothesis that seems to work rather well elsewhere fails entirely in the HTE equation for finished-goods inventories (Table 8-4). None of the regression coefficients here is unambiguously significant, and the signs of some (those of S_t and ΔS_t) are contrary to expectations. Only 16 per cent of the variance of ΔQ_t is accounted for by the equation.

In contrast, the behavior of finished-goods inventories in the production-to-stock sector SDCG conforms well to the hypothesis in terms of the signs and significance of the coefficients of S_t, ΔS_t, and Q_{t-1}. In particular, the coefficient of ΔS_t is here negative and larger absolutely than the (positive) coefficient of S_t. This indicates that passive inventory investment plays a large role in this case and that there are important elements of an inverse relation in the movements of Q_t and S_t.

To conclude this review, the evidence presented does indeed confirm the existence of systematic and important differences in inventory behavior between production to stock and production to order. The differences between stages of fabrication also become more significant when the distinction between the two types of operation is taken into account. These results are not altered by the inclusion in the analysis of some other factors that are apparently much less important as determinants of inventory investment than the orders and shipments variables.[42]

[42] Interest rates are the most important of these factors in Courchene's study. The expected negative effects of interest rates are reported in several of his regressions. In addition to the short-term rates more commonly used in inventory analysis, long-term (corporate bond) rates were used with similar results.

The Supporting Equations for Orders in Recent Models of the Economy

To the extent that new and unfilled orders are included in the comprehensive econometric models, their main function is to contribute to the explanation of inventory changes. Their treatment here is typically rather *ad hoc* and cursory; they are presumptive tools, not objects of interest in their own right. Nevertheless, as endogenous variables in systems of simultaneous equations, orders must themselves be "explained," which introduces a source of potentially important errors (the more so, the greater the role of orders in determining inventory investment and the greater the effects of inventory investment on the short-run fluctuations of the economy at large).

Gary Fromm's quarterly model (1962) includes the following estimated unfilled orders function: [43]

$$\Delta U_t = 111.4 - \underset{(.109)}{.388 S_t^g} + \underset{(.332)}{.523 \Delta S_{t-1}^g} - \underset{(.104)}{.554 U_{t-1}} + \underset{(.101)}{.810 \Delta U_{t-1}}.$$

Fromm proceeds from the identity $\Delta U_t \equiv N_t - S_t$, but his use of GNP final sales, S_t^g, as if it were substitutable for S_t (the much smaller manufacturers' shipments) is at least doubtful. He also uses the definition of ΔU to argue that the coefficient of S_t^g should be negative, but this again is questionable for the same reason. (Moreover, one could maintain that the effect of S_t^g in the above equation is actually positive, though small.) [44]

In the 1964 model by Lawrence Klein, unfilled orders are a function of new orders and the rate of capacity utilization computed from GNP data. The equation,[45] estimated by two-stage least squares, reads

$$U_t = \underset{(44)}{-101} + \underset{(0.84)}{2.12 N_t} + \underset{(55)}{111 (X/X_c)_t},$$

[43] "Inventories, Business Cycles, and Economic Stabilization," in Joint Economic Committee, *Inventory Fluctuations*, Part IV. Some symbols have been changed to conform to the notations used elsewhere in this book: S_t^g denotes final sales of goods in period t (GNP component), and U_t denotes manufacturers' unfilled orders at the end of period t, both in 1954 dollars; Δ stands for quarterly changes.

[44] Fromm lets $N_t = \alpha + \beta S_t^g$, with $\beta < 1$, then states that, since $\Delta U_t \equiv N_t - S_t^g$, $\Delta U_t = \alpha + (\beta - 1) S_t^g$ (*ibid.*, p. 73, n. 38). But ΔU_t is *not* identically equal to $(N_t - S_t^g)$; it equals $(N_t - S_t)$, and S_t certainly differs from S_t^g. As for the estimates reproduced in the text, note that the terms $-.388 S_t^g + .523 \Delta S_t^g$ may be rewritten as $.135 S_t^g - .523 S_{t-1}^g$.

[45] Lawrence R. Klein, "A Postwar Quarterly Model" in *Models of Income Determination* (see also Table 8-2, equation K).

where X is private gross national product, X_c is estimated private GNP at full capacity, and all variables are expressed in billions of 1964 dollars. Since changes in backlogs reflect the varying pressure of demand upon capacity, it is well to find that U is positively related to an independent measure of such pressures, namely, the ratio X/X_c. Relating the simultaneous values of U and N, however, does not result in a very adequate or interesting specification.[46]

An additional equation is then required to explain new orders, and the variables employed by Klein for this purpose are recent "sales of private GNP" (i.e., $X - I_i$, where I_i is inventory investment in billions of 1954 dollars) and recent change in prices (more precisely, in p, the implicit GNP deflator, 1954 = 1.00). The equation, estimated by the limited-information maximum-likelihood method, reads

$$N_t = \underset{(3.2)}{2.56} + \underset{(.010)}{.059}(X - I_i)_{t-1} + \underset{(72.0)}{0.387}(p_t - p_{t-1}).$$

The dependence of new orders on recent price changes is certainly of considerable interest. It could mean that price expectations are formed by projecting past changes, and that attempts to "beat the price hike" and to "wait for better buys" lead to increased ordering after a rise in p and to decreased ordering after a fall in p. But another argument that is relevant at this point was developed in Chapter 7. Price changes are correlated with backlog changes, and the latter lead new orders.[47]

The relationship between new orders and recent "sales," defined broadly as $X - I_i$, may represent an important link in the propagation of demand. However, new orders turn earlier than GNP; so this connection is not likely to be of much help in explaining the tendency of new orders to lead at recessions and revivals in aggregate economic activity. The exclusion of the government component from the "sales" variable could be questioned, since N_t includes defense and other government orders.

The Brookings model in its first version (1965) is similar to others in basing the inventory investment equations on a stock adjustment

[46] Since U, by definition, equals the cumulated total of past differences between N and S, it should be positively associated with N_{t-i} and negatively associated with S_{t-i}, presumably with weights declining with the increasing lags i.

[47] The relation between prices and unfilled orders is actually used in some of the equations designed to explain specific price levels in Klein's model. See Chapter 7, note 52, above and the text discussion thereto.

process, with GNP "final sales" components and manufacturers' unfilled orders cast as the principal explanatory variables.[48] Lagged values of levels and changes in unfilled orders are used, but in most cases the GNP sales terms coincide in timing with the inventory variables. There is disaggregation by production sector (durable manufacturing, nondurable manufacturing, trade, and other), and orders are included in the manufacturing relations only. The model accordingly contains functions for new and unfilled orders in each of the two manufacturing sectors, which adds up to four equations.

Disaggregation in the form used in the Brookings model hurts rather than helps some of these equations when orders and sales are taken with simultaneous timing, because of the interaction between these variables. For example, new orders for durable goods are regressed on the GNP component representing final sales of durables plus new construction. But expenditures follow orders; when the two are taken for the same quarter, it is presumably more appropriate to say that orders determine expenditures than to specify the reverse. A similar form is used for nondurables, where the delivery periods tend to be so short that orders are likely to reflect transactions which are also contained in the nondurable goods component of GNP. Some of the underlying industry equations developed for the Brookings project by Manoranjan Dutta[49] similarly include the gross product originating in the given industry, which again is more a consequence than a source of new orders received by the same group of firms in the same quarter. These specifications seem to have been devised for orders *placed*, not for orders *received*, by the given industry; yet, except for the economy as a whole, the two concepts differ and the available series refer to orders received only.[50]

In short, final sales of durables and nondurables can hardly be viewed

[48] Gary Fromm and Lawrence R. Klein, "The Complete Model: A First Approximation," in J. S. Duesenberry, G. Fromm, L. R. Klein, and E. Kuh, eds., *The Brookings Quarterly Econometric Model of the United States*, Chicago-Amsterdam, 1965, pp. 688–89 and 723.

[49] "Business Anticipatory Demand: An Analysis of Business Orders, 1948–1962," in Duesenberry et al. (eds.), *The Brookings Model*, pp. 162–75.

[50] As Dutta states: "Taking an aggregative view of the production sectors of the economy, orders received and orders placed reduce to the same economic magnitude. This generalization has been a maintained hypothesis of this study" (*ibid.*, p. 175). Dutta's equations for the following industries are open to the criticism given in the text above: electrical machinery (one of the alternative forms offered); transportation equipment, total; motor vehicles and parts; and lumber, furniture, and fixtures. His equations for other industries are not so vulnerable, being based on relations with broad components of GNP.

as determining new orders for these goods received in the same quarter: They are expenditures originating in these or earlier orders. However, where the relations involve lags of new orders behind some suitable comprehensive sales aggregates, the latter may have a valid role to play as causal factors affecting the purchases of industrial products.[51]

Further discussion of the treatment of the orders-inventory relations in econometric models is relegated to Appendix I. This concerns mainly an alternative approach in which, with sales given, inventory accumulation is viewed as a residual from the production operation and is motivated by the objectives of minimizing cost over a time period in the face of fluctuating demand.

Cyclical Fluctuations in Orders and Inventories

Production Requirements and the Timing of Investment in Materials

Abramovitz regarded the inventories of goods "purchased by manufacturers . . . but not yet manipulated by their owners" as being essentially a function of the manufacturers' output.[52] Investment in these stocks, correspondingly, should be primarily a function of the rate of change in output. It would lag behind output changes because of delays in the placement of orders or in the receipt of deliveries. Lags in placing orders occur because changes in the demand for output are not foreseen promptly enough. The availability of materials depends upon the nature and source of supplies but varies over time as well.

Abramovitz had to rely on data with substantial limitations (ten individual commodities for raw materials stocks), but his suggestion that most purchased materials are available with relatively short lags is to some extent confirmed by much more comprehensive recent statistics.

[51] In the Fromm-Klein equations for new orders in the Brookings model, lagged as well as simultaneous values of GNP final sales are used for durable goods, but simultaneous values only are used for nondurables. Relative changes in price indexes from the previous quarter also appear in these estimates with positive coefficients. The unfilled orders equations are again derived from the definition of ΔU as the difference between N and S in any period t, but they use the values of gross product originating in durable and nondurable manufacturing rather than the corresponding values of shipments. This necessitates certain adjustments involving inventory changes in the two sectors. See Fromm and Klein, "The Complete Model," p. 689.

[52] Abramovitz, *Inventories*, p. 178, and Chap. 9.

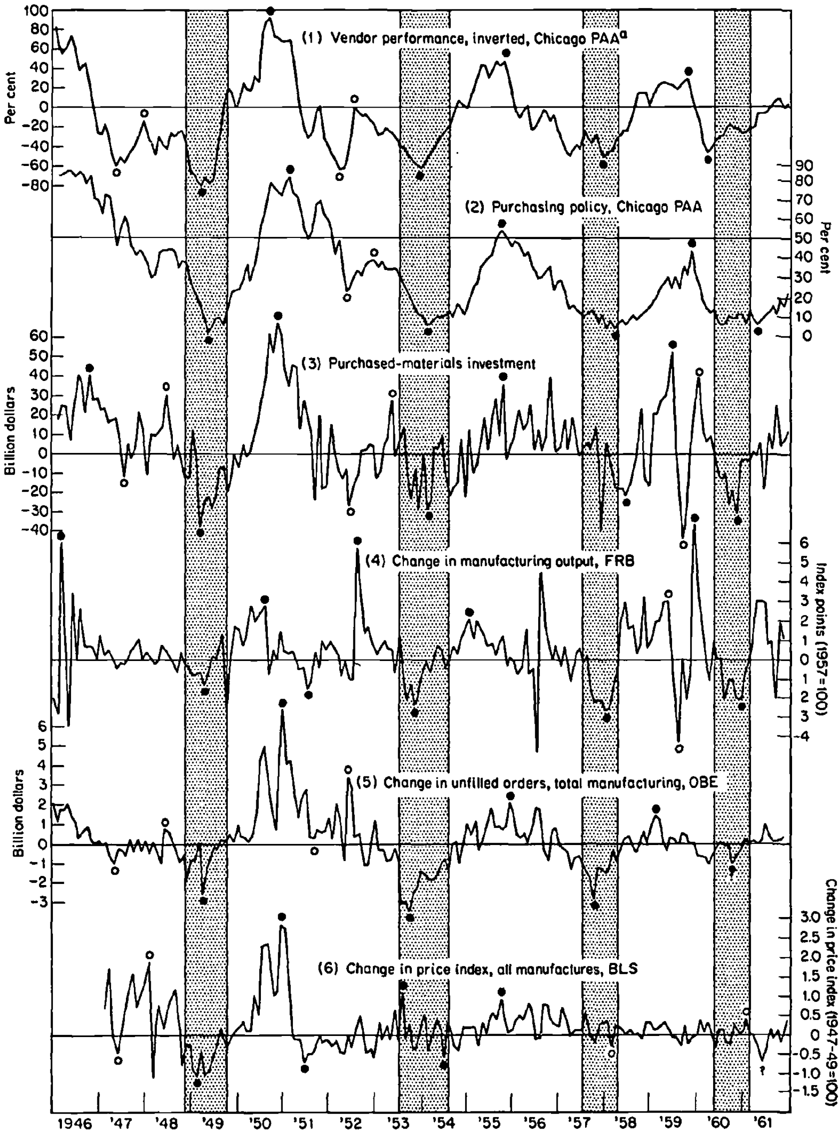
A piece of direct evidence is provided in monthly surveys of the national and regional associations of purchasing agents, in which members report on their buying policy, answering such questions as "How far in advance must you buy in order to have principal materials on hand when needed?" The categories distinguished in these reports have varied somewhat.[53] The results indicate that ordering for 60 days or less is often taken to denote coverage of known requirements rather than buying ahead for future needs (which would presumably be but vaguely recognized or unknown). However, in the immediate postwar period of strong demand pressures and serious supply shortages, the range of 30 to 90 days was sometimes implicitly treated as the period for normal purchasing commitments. As shown in Chart 8-2 (curve 2), an index of the percentage of firms reporting advance commitments for 60 days or more shows wide fluctuations, declining very markedly in each recession. But except in the early postwar period 1946–47, the Korean boom of 1950–51, and a few months late in 1955, most of the participating firms were buying materials for no longer than two months in advance, or less.[54] This evidence is consistent with the observation made earlier that the bulk of purchases for inventory probably involve short delivery periods.

The lags obtained by comparing turning points are often a good deal longer than would be indicated by the above measures. Turns of purchased-material investment lagged behind those of the change in output by quite variable intervals averaging nearly four months for total manufacturing in 1946–61 (Table 8-5, column 3). At peaks, these lags were somewhat longer than at troughs. The irregularity of these measures as well as the duration of the lags do not accord well with the hypothesis that purchased-stock movements are altogether dominated by output changes. The greatest irregularity is in the nondurable goods industries. This may be partly due to the relatively strong influence of independent changes in agricultural supply conditions. However, the

[53] Thus, right after the war the Chicago survey categories were: hand to mouth, 30 days, 60 days, 90 days, 4 to 6 months, and longer. Later, a better-defined classification was used: 0 to 30 days, 30 to 60 days, 60 to 90 days, and 90 days or longer.

[54] In Chart 8-2, the Chicago purchasing policy data are used because they can be compared with the vendor performance index, which is available only from this regional survey, and because the Chicago series could be extended back to 1946. As far as can be established, the Chicago figures relate consistently to principal materials needed by the highly diversified industry of the region. The cyclical movements of the Chicago index and the national index based on the surveys of the National Purchasing Agents Association are quite similar. The NPAA index begins in 1950; it is shown through 1958 in Stanback, *Postwar Cycles*, Chart 9.

Chart 8-2
Vendor Performance, Purchasing Policy, Purchased-Materials Investment, and Changes in Manufacturers' Output, Unfilled Orders, and Prices, 1946–61



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

[a] Percentage reporting slower deliveries minus percentage reporting faster deliveries. See text.

duration of the lags certainly cannot be explained by technical factors such as time required for transportation and production of materials. One must consider the factors bearing on the manufacturer's decision to buy more or less material at a particular time.

Expectations, Sales Terms, and Purchasing Policy

In the real business environment, which is one of changing trends and fluctuations and of pervasive uncertainty, cyclical turns in sales are seldom very promptly *recognized*, let alone correctly *predicted*. The inability to forecast sales correctly with sufficient lead time can help explain the lags of materials inventories at cyclical turns in sales and production. But changes in backlogs of unfilled orders and in conditions of availability of materials also are instrumental here.

Chart 8-2 and Table 8-5 provide some evidence bearing on these relations. The vendor performance series has already been introduced as a diffusion index of changes in the delivery period—the excess of the percentage of purchasing agents reporting slower deliveries over the percentage reporting faster deliveries. Comparison of series 1 and 3 in Chart 8-2 suggest a substantial correlation between the cyclical movements in vendor performance and in purchased-materials investment (allowing for the much greater strength of the erratic component in the latter than in the former series). But the vendor performance index moves up and down earlier than materials investment (Table 8-5, column 1). In 1946–61, the index led investment nine times, and the two series coincided twice. Most of the leads were in the range of two to six months, and the average was about four months.

The purchasing policy index, showing the proportion of firms in the Chicago PAA survey that buy for 60 days ahead or more, is also positively correlated with materials investment with respect to cyclical movements, although it too is much less erratic than the investment series (compare curves 2 and 3 in Chart 8-2). But this index does not systematically lead (or lag behind) investment in purchased commodities; rather, the two series tend toward roughly coincident timing (see Table 8-5, column 2).

As implied by these observations, purchasing policy lags behind vendor performance. Direct comparisons show that these lags have been quite persistent and mostly, but not always, short. They varied

Table 8-5
Timing of Selected Series at Turning Points in Manufacturers' Investment in Purchased Materials, 1947–60

Date of Turn in Purchased Materials Investment			Lead (−) or Lag (+), in Months				
			Vendor Performance (1)	Purchasing Policy (2)	Change in Mfg. Output (3)	Change in Mfrs. Unfilled Orders (4)	Change in Mfg. Price Index (5)
Trough	July	1947[a]	−2[b]	[c]	[d]	−2[b]	−3[b]
Peak	June	1948[a]	−6[b]	[c]	[d]	0[b]	−5[b]
Trough	March	1949	0	+2	+1	+1	−1
Peak	Nov.	1950	−2	+3	−3	+2	+1
Trough	June	1952[a]	−3[b]	−1[b]	−11	−9[b]	−12
Peak	May	1953[a]	−10[b]	−5[b]	−9	−11[b]	+2
Trough	Feb.	1954	−2	+1	−3	−4	+4
Peak	Oct.	1955	0	−1	−9	+2	−1
Trough	June	1958	−6	−3	−5	−8	[e]
Peak	June	1959	[f]	[g]	−1	−4	n.t.
Trough	Sept.	1959[a]	n.t.	n.t.	−1[b]	n.t.	n.t.
Peak	Jan.	1960[a]	−3[f]	−2[g]	−1[b]	n.t.	n.t.
Trough	Nov.	1960	−8	+5	+1	−1	n.t.
Average timing[h]							
Peaks			−4.2	−1.2	−4.6	−2.2	−0.8
			(3.0)	(2.2)	(3.5)	(4.2)	(2.2)
Troughs			−3.5	+0.8	−3.0	−3.8	−3.0
			(2.3)	(2.2)	(3.3)	(3.2)	(4.5)
All Turns			−3.8	−0.1	−3.7	−3.1	−1.9
			(2.7)	(2.5)	(3.5)	(3.7)	(3.6)

n.t. = no turn.

[a] Minor rather than cyclical turn in purchased materials investment.

[b] The turning point in the series compared with purchased materials investment is minor rather than cyclical.

[c] The July 1947–June 1948 rise in purchased materials investment cannot be matched with a corresponding movement in purchasing policy. Note, however, the weak increase in the latter series between February and July 1948 and compare the rise in materials investment between January and June 1948 (Chart 8-2).

[d] Change in manufacturing output shows only a small increase between May and November 1947, i.e., shortly prior to and partly overlapping with the early part of the rise in investment (Chart 8-2). No turning point comparisons are made.

[e] No cyclical turning points in the price-change series are distinguished in the period 1957–60 (cf. Chart 8-2 and text with note below).

[f] The peak in vendor performance lags behind the June 1959 peak in investment by

four months but it would be more appropriate to match it with the secondary January 1960 peak in investment, which yields a lead of three months (Chart 8-2).

[g] The peak in purchasing policy lags behind the June 1959 peak in investment by five months, but it would be more appropriate to match it with the secondary January 1960 peak in investment, which yields a lead of two months.

[h] Average deviations, in months, are given in parentheses.

from two to five months, with three exceptions, and averaged 3.7 months.[55]

The difference in relative timing between the vendor performance and the purchasing policy index is interesting because of its consistency with the presence of what was called earlier the supply conditions effect; that is, when industrial buyers perceive a lengthening of the average delivery periods quoted by their suppliers, they will soon attempt to place more long-term orders to protect themselves against possible shortages in the future. Conversely, when sellers start quoting shorter delivery periods again, buyers will relax and begin reducing the average length of their purchasing commitments. Of course, the relation is really a good deal more complicated, for it is definitely one of mutual dependence and reinforcement rather than unidirectional. An extension of quoted delivery periods may induce more long-term buying, but it also means in itself an enforced increase of the share of advance orders in total purchases.

When more than 50 per cent of suppliers are reported to make slower deliveries, this is usually a symptom of increased pressures of demand upon capacity, and so is an accelerated expansion of unfilled orders. When the pressure subsides, the net percentage of slower deliveries begins to decline, and a retardation occurs in the backlog accumulation. Investment in purchased-materials inventories is positively correlated with the backlog change (curves 3 and 5), in part because the desired volume of these stocks increases with unfilled orders for the firm's products and in part because of the effects on buyers' behavior of changes in availability as reflected in the vendor performance index. Backlog change leads purchased-materials investment irregularly by approximately three months on the average (Table 8-5, column 4).

[55] Altogether, in the 1947–60 period, these comparisons include two lags of 2 months each, two of 3 months, and two of 5 months, one of 1 month, and one of 13 months; and one lead of 1 month. The averages at peaks and troughs are lags of 2.5 and 4.6 months, respectively.

Investment in purchased materials appears to be more loosely associated with the change in the price index for all manufactures than with any of the other series plotted in Chart 8-2. This is consistent with the results frequently obtained in the regression studies, but much doubt remains. It must be reiterated that the wholesale price data commonly used in this work probably understate considerably the cyclical price flexibility. The one period in which investment in materials and the change-of-price index moved in markedly similar fashion was the early phase of the Korean War (1950–51).[56]

The relationship that emerges from this analysis is a rather complex one in which fluctuations in materials inventories depend on a number of factors such as the changes in output, availability of materials, backlogs, and prices. One can identify some periods (e.g., during most of 1955) in which purchased-materials investment moved contrary to output change and apparently in consonance with changes in order backlogs, availability, and prices. At other times, for example, in the last half of 1959 under the impact of the steel strike (see Chart 8-2), investment in materials and the change in output paralleled each other, while the other series behaved quite differently.

Estimates for Materials Stocks on Hand and on Order

There are no direct estimates of outstanding purchase orders for materials, but the new Census data available for the period since 1953 provide a usable approximation: the series on unfilled sales orders held by manufacturers, classified into the market categories "construction materials and supplies" and "other materials and supplies." Consequently, the sum of these two series will be taken to represent the "stock on order" of the purchasers of materials, i.e., their outstanding orders, *OUM*. The stage-of-fabrication breakdown of total manufacturers' inventories gives direct estimates of the "stock on hand," i.e., the inventories of materials and supplies actually held by users, *M*. Estimates of total "ownership" of materials, *OWM*, can be obtained by simple addition of the identically dated, consecutive values of *M* and *OUM*.

[56] Our investment series reflects quantity as well as price changes, of course, and the latter were exceptionally large at the time. The same circumstance helps to explain the relative weakness in this period of the association between materials investment and the output change; the use of deflated figures would make the bulge in investment smaller and more similar to the 1950 contour of the output-change series. See Stanback, *Postwar Cycles*, Chart 6.

Changes in stocks on hand and in stocks on order should occur in response to a set of common factors, but the elasticities and the lags involved could well be different for the two components of materials ownership. For example, outstanding orders may be subject to prompter changes and more effective control than materials inventories on hand. Several questions in this context can be addressed to the new data, and the following analysis marks a limited effort in this direction.

Table 8-6, based on quarterly, seasonally adjusted data, presents regressions of M_t, OUM_t, and OWM_t on the following independent variables: current shipments or lagged new orders of all manufacturers (S_t or N_{t-1}, used as alternatives); unfilled orders, also for total manufacturing, as of the end of the preceding quarter, U_{t-1}; bank rate on short-term business loans, similarly dated, i_{t-1}; change from the previous quarter in the price index of intermediate materials and supplies, ΔPM_t; and the lagged value of the dependent variable (M_{t-1} or OUM_{t-1} or OWM_{t-1}).[57] Negative coefficients are expected for the interest rate, positive coefficients for the other factors. The signs of the estimated coefficients agree with these expectations in each case, except that the impact of i_{t-1} in the inventory regressions is significantly positive.

The positive dependence of M_t on N_{t-1} in an equation that also includes U_{t-1} and M_{t-1}, among others, confirms that an increase in the demand for outputs that require materials results on the average in a rise of the desired relative to the actual stock of materials. When S_t is used to replace N_{t-1}, it acquires a similar positive (and highly significant) coefficient that reflects essentially the same relationship.[58] An advantage of using N_{t-1} is that a predictive lead is gained that is absent in the application of S_t. Moreover, in the estimates for outstanding orders and for total stocks on hand and on order, it is the equations with N_{t-1} rather than S_t that produce the better statistical results, although

[57] The stock variables (M, OUM, OWM, U) and the price variables (PM, i) are last-month values in each calendar quarter; the flow variables (S, N) are quarterly averages of monthly data. The interest rate, i, is a weighted average for a selected sample of banks in nineteen cities (Federal Reserve). The price series, PM, covers intermediate materials, supplies, and components purchased by manufacturers; it is a wholesale price index for one stage of processing, 1957–59 = 100 (U.S. Department of Labor, Bureau of Labor Statistics). The other data are taken from U.S. Department of Commerce, Bureau of the Census, *Manufacturers' Shipments, Inventories, and Orders: 1947–1963 (Revised)*, Washington, D.C., 1963, and the recent issues of the *Survey of Current Business;* all are in millions of dollars.

[58] S_t and N_{t-1} are, of course, highly correlated ($r = .992$). The regression with S_t yields a higher $\bar{R}^2$ than that with N_{t-1}, but the difference is quite small (Table 8-6, columns 1 and 2).

Table 8-6
Regressions for Inventories, Outstanding Orders, and Total Inventories on Hand and on Order of Materials Purchased from Manufacturers, Quarterly, 1954–66

Constant Term (1)	S_t (2)	N_{t-1} (3)	U_{t-1} (4)	i_{t-1} (5)	ΔPM_t° (6)	Lagged Dependent Variable[a] (7)	$\bar{R}^2$ (8)
			ESTIMATES FOR INVENTORIES (M_t)[b]				
1,746.5	.109		.026	5.566	2.561	.532	.982
(600.1)	(.019)		(.007)	(1.694)	(0.910)	(.088)	
1,785.3		.097	.022	5.103	2.417	.574	.980
(673.5)		(.020)	(.007)	(1.785)	(0.988)	(.092)	
			ESTIMATES FOR OUTSTANDING ORDERS (OUM_t)[c]				
1,304.9	.182		.271	−14.461	7.600	.382	.940
(1,816.2)	(.055)		(.141)	(5.008)	(3.800)	(.272)	
2,218.5		.204	.251	−16.524	6.354	.405	.945
(1,809.2)		(.052)	(.135)	(4.856)	(3.708)	(.258)	
			ESTIMATES FOR INVENTORIES ON HAND AND ON ORDER (OWM_t)[d]				
3,992.0	.322		.347	−5.428	9.914	.307	.964
(1,651.7)	(.054)		(.134)	(6.470)	(3.697)	(.235)	
5,326.1		.341	.366	−6.337	8.420	.251	.967
(1,626.6)		(.051)	(.126)	(6.107)	(3.533)	(.223)	

Note: Standard errors of the coefficients are given underneath in parentheses. S, N, and U denote, respectively, the current-dollar values of shipments, new orders, and unfilled orders, for total manufacturing; i is the bank rate of interest on business loans in nineteen cities; ΔPM is the change in the wholesale price index for intermediate materials, supplies, etc. ($\Delta PM_t^\circ = \Delta PM_t \times 100$; see text and note 70).

[a] M_{t-1} for the equations in the first two lines; OUM_{t-1} for third and fourth lines; and OWM_{t-1} for last two lines. See notes b, c, and d, following.

[b] The dependent variable M_t = purchased-materials inventories, total manufacturing.

[c] The dependent variable OUM_t = unfilled orders of the market category "materials, supplies, and intermediate products" (see text).

[d] The dependent variable $OWM_t = M_t + OUM_t$.

again the differences are marginal. Outstanding orders for materials appear to be generally more sensitive than the inventories to changes in demand, which is consistent with the notion that firms can adjust OUM considerably better than M.[59]

[59] The short-run elasticities at the point of the means with respect to S_t, N_{t-1}, and U_{t-1}, respectively, are: for M_t, 0.177, 0.157, and 0.072 or 0.060; for OUM_t, 0.240, 0.266, and 0.600 or 0.555;

Unfilled orders of manufacturers at the end of the preceding quarter have in each case a significant positive effect on the current inventories and/or outstanding orders of materials (column 4). It should be noted, however, that the partial correlations for U_{t-1} are not high and are smaller throughout than those for either S_t or N_{t-1}.[60]

The net impact of changes in the bank rate on business loans on materials stocks on hand is quite significant but positive, according to both the first and the second equation in Table 8-6. However, stronger negative effects are obtained for i_{t-1} in the regressions for outstanding orders (particularly in the estimates with N_{t-1}).[61] Since negative coefficients are expected, this finding, if valid, would again suggest that adjustments are made more promptly and with greater success in outstanding orders than in the physical stock of materials. For the aggregate of stocks on hand and on order, the results are mixed: The coefficients of i_{t-1} are negative but very low relative to their standard errors.

If price expectations have large extrapolative components, so that rises in the level of materials prices are associated with forecasts of further rises, at least some of the firms would probably attempt to hedge against or beat the price hike by accelerating their purchases in periods of inflationary developments. The evidence on the presence of such "speculative" behavior is mixed, as reported before (see text and Tables 8-2 and 8-3). Our estimates in Table 8-6, column 6, show fairly significant coefficients of the price-change variable ΔPM_t, with the expected positive signs. Since the measured price index changes are very small, their coefficients in absolute value are large, and it seemed advisable to apply a scale factor to this variable.[62] It is pos-

for OWM_t, 0.234, 0.246, and 0.425 or 0.448. (The first of the estimates for U_{t-1} refers to the equations with S_t, the second to those with N_{t-1}.) The elasticity of OUM_t to U_{t-1} is relatively high, but this must be discounted because total backlogs represent a massive aggregate that includes outstanding orders for materials. (The simple correlation between OUM_t and U_{t-1} is 0.953. The average value of U in the regression period was $55.3 billion; of OUM, $24.7 billion.)

[60] The highest of these partials with U_{t-1} are .499, .281, and .404 for M_t, OUM_t, and OWM_t, respectively, whereas the corresponding partials with S_t are .659, .450, and .672, and those with N_{t-1} are .604, .514, and .716.

[61] The partial correlations of i_{t-1} with M_t and OUM_t are .400 and −.461, respectively (this is for the equations with N_{t-1}; the estimates for the equations with S_t are .448 and −.403). The corresponding elasticity figures are .122 and −.318 (or .133 and −.278).

[62] That is, the estimates in Table 8-6 refer to $\Delta PM_t^a = 100 \times \Delta PM_t$. Had the observed changes been used without this adjustment, the coefficients in column 6 would have been 100 times larger, ranging from 241.74 to 991.36. A casual glance at such large values could be misleading—suggestive of stronger effects than are actually involved. The partial correlations, for example, are rather low, varying from .253 to .394.

sible that this factor operates with longer and more complex lags, but the evidence on this point is fragmentary and at best only suggestive.[63]

In the first equation of Table 8-6, subtracting the coefficient of M_{t-1} from 1.000 gives 0.468, which, when interpreted in accordance with the flexible-accelerator model, means that a little less than one-half of the discrepancy between the available and desired stock of materials would on the average be targeted for correction within one quarter of a year. The corresponding fraction is somewhat lower (0.426) for the second equation, which includes N_{t-1} instead of S_t. Some other inventory studies estimate the adjustments to be much slower than that, but the sluggishness thus implied seems to me rather implausible.[64]

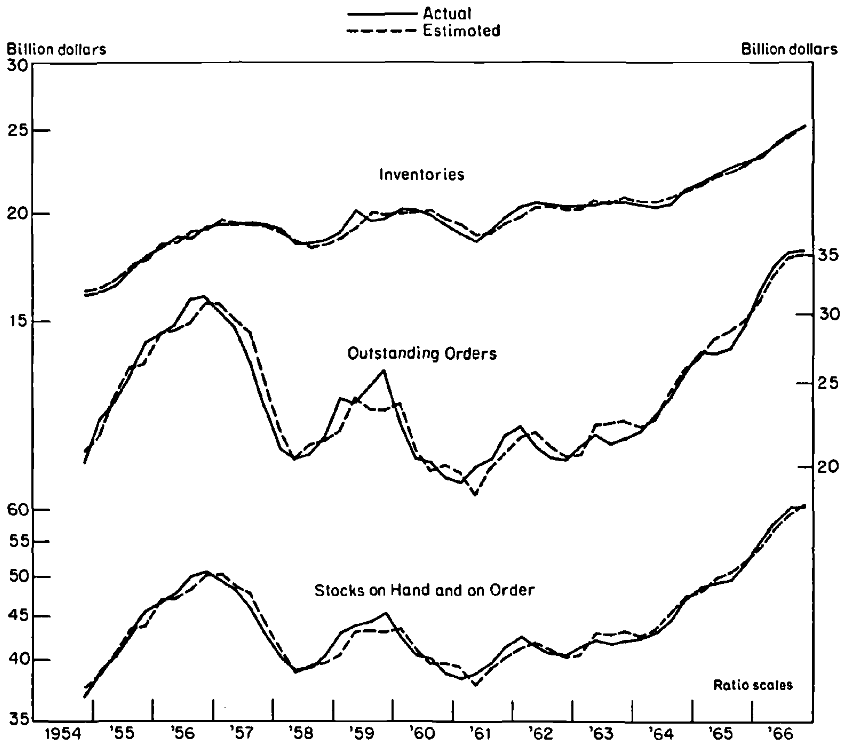
One would expect the adjustments to be speedier for outstanding orders than for stocks on hand, and the estimates in column 7 of Table 8-6 are consistent with this hypothesis in that the coefficients of OUM_{t-1} are lower than those of M_{t-1}. The regression results suggest that about 0.6, or a slightly higher fraction, of the gap between the actual and the planned level of outstanding orders would on the average over time be corrected in any one quarter. (However, unlike the coefficients of M_{t-1} in the estimates for inventories, the coefficients of OUM_{t-1} have relatively large standard errors; they are significantly different from zero at the 10 per cent but not at the 5 per cent level, according to one-sided t tests. In the equations for total stocks on hand and on order, the coefficients of OWM_{t-1} are still lower absolutely and relative to their standard errors.)

Chart 8-3 compares the actual values of inventories, outstanding orders, and stocks on hand and on order of materials and supplies with the corresponding estimates based on the equations from Table 8-6, lines 2, 4, and 6 (these are the regressions that include the new orders variable N_{t-1}). It is clear that the fits, which are somewhat better for M and OWM than for OUM, are generally close. Relatively large residuals and differing patterns in actuals and estimates are observed in 1959. However, the major steel strike then in progress created unusually severe disturbances. Even so, the calculated values tend to lag behind by a quarter at the turns in the recorded values and to under-

[63] The effects of ΔPM_{t-1} approximate those of ΔPM_t in the equations for outstanding orders, but they are considerably weaker and of low or doubtful significance in the equations for stocks on hand.

[64] The result here is similar to that obtained by Lovell in his all-manufacturing regression for materials and goods in process (see Table 8-3, first line).

Chart 8-3
Actual and Estimated Values of Inventories, Outstanding Orders, and Total Stocks on Hand and on Order of Materials and Supplies, Quarterly, 1954–66



Source: See Table 10-6.

(over-) estimate the actual levels in periods of rise (decline). It should be recalled again that errors of this type are common in estimates from regression equations that include lagged values of the dependent variable.

The graphs of the compiled series are interesting in their own right, and their main features conform to expectations rather reassuringly. Thus, there is considerable similarity between the cyclical movements of inventories and those of outstanding orders, but the latter have a marked tendency to lead the former and also have much larger relative amplitudes. This presumably reflects the greater adaptability of stocks on order, which results in their being much more sensitive than stocks on hand to cyclical changes in the demand for output and other factors.

Additional Variables and Investment Equations for Materials

Conceivably, errors that the firms are making in forecasting their sales could affect their inventories or outstanding orders of materials or both, although the importance of this factor has been established only for finished stocks. The difference between current shipments and previous new orders of manufacturers may provide a simple estimate of such errors, that is, $E_t = S_t - N_{t-1}$. When included as an additional variable in such inventory equations as those used in Table 8-6, E_t shows positive coefficients; its effect appears to be statistically significant in the model with N_{t-1} but not in that with S_t. In regressions for outstanding orders analogous to those reported in the table, the coefficients of E_t are negative and significant at least at the 5 per cent level.[65]

If the coefficient of E_t in an equation for M_t is viewed as an estimate of that fraction of the forecasting error that results in passive inventory investment, its sign should be negative: When shipments exceed expectations, for example, the rate of production would be increased and the stock of materials somewhat depleted. The import of such a development on outstanding orders for materials is, however, not clear: If faster delivery on these orders is requested and provided, this would tend to reduce OUM_t, but at the same time the unexpected improvement in their sales might induce the firms to place more orders with their suppliers, which would tend to increase OUM_t.

On this reading, therefore, the observed coefficients of E_t in the inventory equations have the wrong sign, and those in the outstanding orders equations describe net balance effects of opposite tendencies. In any event, E_t contributes little to the over-all correlations ($\bar{R}^2$) and, generally, little seems to be lost when it is omitted. It may be, of course, that E_t is an overly crude or inappropriate measure of sales anticipation errors.[66]

[65] The coefficient of E_t in the inventory regression with S_t is .031 (±.057); the corresponding estimate in the regression with N_{t-1} is .139 (±.059). For outstanding orders, the coefficients of E_t are −.583 (±.223) and −.398 (±.228) in the regressions with S_t and with N_{t-1}, respectively. (The figures in parentheses are the standard errors of the coefficients.)

[66] In particular, E_t as defined is bound to interact with S_t (or N_{t-1}). Let a be the directly estimated coefficient of S_t and b that of E_t in an equation that includes these variables along with others. Then the implicit net coefficients are $a + b$ for S_t and $-b$ for N_{t-1}. If one starts from an equation that in-

Significant changes in the prevailing delivery periods for materials and supplies are certainly likely to influence outstanding orders for these goods. For example, the immediate impact of an over-all lengthening of these lags should be to reduce the rate of deliveries, which tends to increase the amount of orders outstanding. This effect may later be reinforced if users place more orders for materials to protect themselves against possible shortages. The influence of changes in the average delivery period for materials on inventories M is more indirect and should be weaker; moreover, here reactions in the opposite direction can be more readily envisaged.[67]

The average delivery lag for materials may be approximated by the ratio of unfilled orders to shipments for the industries that produce materials, that is, $DL_t = OUM_{t-1}/DM_t$. A quarterly series of such ratios can be computed from the new Census market-category data.[68] When DL_t is included along with the other variables from Table 8-6 in the inventory equations, it has in each case a negative coefficient, which, however, is definitely not significant, since the coefficient is smaller than its standard error. Since no strong effect of this factor on M had been expected, this result is not implausible. When DL_{t-1} is similarly added to the equations for outstanding orders, the results are not meaningful; indeed, the relationships estimated in Table 8-6 for OUM_t are then thoroughly disrupted (the coefficients of S_t and N_{t-1} become negative!). This is apparently because of the interaction of DL_{t-1} with the lagged value of the dependent variable, OUM_{t-1}, and the backlog of unfilled orders of manufacturers, U_{t-1}. When these two factors are omitted, DL_{t-1} enters the regression with a highly significant positive coefficient, and the remaining variables also have relatively large coefficients with the expected signs. When either U_{t-1} or OUM_{t-1} is

cludes N_{t-1} and E_t, their measured effects will be a and $a + b$, respectively, which implies the same net coefficients as before for S_t and N_{t-1}. The coefficient of S_t (or N_{t-1}) in the regression for inventories that includes E_t is .108 (±.019); the corresponding estimate in the regression for outstanding orders is .185 (±.052). These figures are extremely close to the coefficients for S_t in the first and third lines of Table 8-6. The coefficients of the other variables are only very slightly affected by the inclusion of E_t.

[67] The same demand pressures that generate an increase in the delivery lags may also cause the rates of utilization of materials to rise. The latter factor would work to reduce the stocks of materials on hand.

[68] The series combines data for two categories, as identified early in the previous section. The unfilled (= outstanding) orders, OUM, are as of the last month of the quarter ($t - 1$) when the shipments (deliveries) of materials, DM, refer to the tth quarter. Most of the time, the delivery periods for materials and supplies are relatively short; they average 1.607 months, with a standard deviation of 0.297.

readmitted, the coefficient of DL_{t-1} becomes negative. This suggests that the backlog variables (and perhaps also the price change, ΔPM) act in part as proxies for the variation in delivery periods. Lags in delivery of materials probably do have some positive influence on materials orders outstanding, but it is difficult to separate that influence from the effects of the other variables.

When net changes (investment) in stocks of materials (ΔM_t, ΔOUM_t, ΔOWM_t) are used as dependent variables instead of the stocks proper (M_t, OUM_t, OWM_t), with the independent variables the same as in the equations of Table 8-6, the regression estimates in columns 1–6 of that table remain unchanged. If the coefficient of the lagged stock term (Table 8-6, column 7) is set equal to $1 - b$, the coefficient of the same variable in the corresponding investment equation is $-b$ (see note 18 above). The correlation coefficients are, of course, considerably lower for the investment regressions than for the stock regressions. Thus, those versions of the former that include N_{t-1} give R^2 coefficients of .609, .520, and .636, which may be compared to R^2 values of .982, .951, and .971 for the regressions in Table 8-6, in the second, fourth, and sixth lines, respectively.

It is interesting to examine the consequences of adding to each of the investment equations the lagged value of its dependent variable.[69] Table 8-7 shows that they are minor for inventory investment: The coefficient of ΔM_{t-1} is not much larger than its standard error, and the inclusion of ΔM_{t-1} raises $\bar{R}^2$ from .564 to .574 only. The coefficients of the other variables are virtually unaffected (compare the corresponding entries in Table 8-7, first line, and Table 8-6, second line). On the other hand, the estimates for investment in stocks on order are strongly influenced by the addition of ΔOUM_{t-1}: $\bar{R}^2$ is raised from .465 to .598; the coefficients of U_{t-1} and OUM_{t-1} are increased, while those of the other variables are substantially reduced; and the statistical significance of N_{t-1} and ΔPM_t° is now in doubt (see Table 8-7, second line, and Table 8-6, fourth line). Thus the model used previously is shown to be quite vulnerable in this case. This is disturbing, but it may well be that the revealed weakness is due mainly to inadequate specification of the lag structure in the model.

[69] Flexible-accelerator models that include both lagged capital stock and lagged investment have been considered in John R. Meyer and Robert R. Glauber, *Investment Decisions, Economic Forecasting and Public Policy*, Boston, 1964 (cf. note 27 in Chapter 10 below).

Table 8-7
Regressions for Investment in Materials Inventories, Outstanding Orders, and Inventories on Hand and on Order, Quarterly, 1954–66

	Regression Coefficients							
Dependent Variable	Constant Term (1)	N_{t-1} (2)	U_{t-1} (3)	I_{t-1} (4)	ΔPM_t^o (5)	Lagged Stock Level[a] (6)	Lagged Dependent Variable[b] (7)	$\bar{R}^2$ (8)
ΔM_t	1,964.1	.093	.019	5.377	2.412	−.430	.158	.574
	(677.2)	(.020)	(.007)	(1.774)	(0.976)	(.091)	(.111)	
ΔOUM_t	1,094.7	.077	.428	−8.552	3.679	−.937	.520	.598
	(1,594.5)	(.056)	(.126)	(4.679)	(3.286)	(.240)	(.133)	
ΔOWM_t	5,845.3	.242	.365	1.878	5.193	−.760	.450	.698
	(1,407.7)	(.050)	(.109)	(5.510)	(3.150)	(.192)	(.113)	

Note: Standard errors of the coefficients are given underneath in parentheses. For an explanation of the symbols, see the note to Table 8-6.

[a] M_{t-1} for the equation in the first line; OUM_{t-1} for the second line; and OWM_{t-1} for the last line.

[b] ΔM_{t-1} for the equation in the first line; ΔOUM_{t-1} for the second line; and ΔOWM_{t-1} for the last line. See Table 8-6, notes a, b, and c. Quarter-to-quarter change is denoted by Δ.

The results for investment in total materials stocks on hand and on order are more satisfactory. The over-all correlation is here fairly high for an equation with first differences ($R^2 = .736$), and all but two of the regression coefficients are more than three times larger than their standard errors. However, ΔPM_t^o is considerably less effective here than in the equation without ΔOWM_{t-1}, and the coeffcient of i_{t-1} becomes positive and is reduced to a fraction of its standard error (compare Tables 8-7 and 8-6).

Estimates in Real Terms

At least some of the aspects of inventory behavior require in principle an analysis in terms of physical quantities or price-deflated values, a notable example being the possible price-change effects on inventory policies. An attempt was therefore made to discover what may be expected in the present context from the use of series expressed in constant dollars. The very limited scope and purpose of this effort must be emphasized, along with the need to recognize that deflation of aggregative data on stocks and orders presents particularly difficult estimation problems and may result in large measurement errors.

The price index *PM* for materials has been used as a deflator for the dependent variables, to produce the series in constant (1957–59 = 100) dollars, M^*, OUM^*, and OWM^*. The all-manufacturing series have been deflated by means of the wholesale price index for manufactured products.[70]

The models underlying Table 8-6 were then re-estimated with the constant-dollar series replacing the current-dollar ones. Table 8-8, lines 1–3, shows the results for the equations that include N_{t-1} (cf. with Table 8-6). The coefficients of N^*_{t-1}, U^*_{t-1}, and the lagged values of the dependent variables are very close indeed to the coefficients of N_{t-1}, U_{t-1}, etc., in Table 8-6. The coefficients of i_{t-1} are also similar in the two sets of regressions. However, the significance of the coefficients of ΔPM°_t is considerably reduced in the estimates with price-deflated data, suggesting that some (but by no means all) of the previously observed effects of this variable must be attributed to the purely nominal movements of the value aggregates for stocks on hand and/or on order. The values of $\bar{R}^2$ in the two tables differ very little.

Rising prices may offset some of the increase in the cost of borrowing (and gains from lending) that result from rising interest rates. To the extent that inflationary expectations existed in the period surveyed, the deterrent effect of increasing interest costs was presumably blunted. It seemed advisable, therefore, to examine the effectiveness in the constant-dollar equations of the *real* interest rate i^*; but since this variable involves the *expected* changes in the general price level, it is not directly observable. The measure of i adopted here is the nominal rate minus the last actual change in prices, both expressed in percentages per year, but this proxy may be a poor one.[71]

As shown in the last three lines of Table 8-8, the coefficients of i^*_{t-1} are all negative, but the one in the inventory regression is not significantly different from zero. The coefficient of ΔPM°_t in the same regres-

[70] Asterisks denote the deflated series. That is, $M^*_t = 100\ (M_t/PM_t)$, $N^*_t = 100\ (N_t/P_t)$, etc. (where *PM* is the price index for materials and *P* the index for all manufactured products).

[71] The price series used in this computation of i^* is the all-manufacturing price index *P*. While not as comprehensive as might be desired, this index was deemed representative enough for our purpose.

Table 8-8

Regressions for Inventories, Outstanding Orders, and Inventories on Hand and on Order of Materials, Based on Data in Constant Dollars, Quarterly, 1954–66

Line	Dependent Variable	Constant Term (1)	Regression Coefficients N^*_{t-1} (2)	U^*_{t-1} (3)	i_{t-1} (4)	i^*_{t-1} (5)	ΔPM°_t (6)	Lagged Dependent Variable[a] (7)	$\bar{R}^2$ (8)
1	M^*_t	29.451	.091	.024	4.756		1.046	.526	.967
		(8.111)	(.015)	(.007)	(1.348)		(0.899)	(.090)	
2	OUM^*_t	4.579	.218	.282	−13.458		4.185	.331	.939
		(20.275)	(.053)	(.142)	(4.542)		(3.764)	(.277)	
3	OWM^*_t	52.625	.348	.377	−4.602		6.498	.212	.968
		(16.454)	(.039)	(.116)	(4.466)		(3.074)	(.209)	
4	M^*_t	24.097	.099	.011		−0.108	−0.176	.696	.959
		(9.665)	(.022)	(.008)		(0.235)	(0.992)	(.089)	
5	OUM^*_t	−13.163	.130	.413		−2.606	9.222	−.005	.943
		(16.073)	(.033)	(.129)		(0.754)	(3.016)	(.252)	
6	OWM^*_t	71.945	.359	.399		−2.061	5.673	.104	.965
		(18.039)	(.049)	(.099)		(0.714)	(2.909)	(.175)	

Note: Standard errors of the coefficients are given underneath in parentheses. For an explanation of the symbols, see the note to Table 8-6, the accompanying text, and also text notes 70 and 85.

[a] M^*_{t-1} for the equations in lines 1 and 4; OUM^*_{t-1} for those in lines 2 and 5; and OWM^*_{t-1} for those in lines 3 and 6.

sion is also negative and smaller than its standard error. In the equations for OUM^* and OWM^*, however, both i^*_{t-1} and ΔPM°_t appear with significantly large and properly signed coefficients. These estimates appear quite reasonable and so, once more, the results for stocks on hand and on order are more satisfactory than those for stocks on hand alone. In other respects, the substitution of i^*_{t-1} for i_{t-1} apparently makes little difference.[72]

[72] The lagged values of the dependent variables are entirely ineffective in the equations with the real interest rate for OUM^* and OWM^*; their coefficients in the corresponding equations with i_{t-1} are larger, but they barely exceed their standard errors (compare the appropriate entries in column 7). The coefficients of N^*_{t-1} and U^*_{t-1} are not affected substantially or systematically. The substitution yields a slightly higher $\bar{R}^2$ in the regression for OUM^*, and a slightly lower $\bar{R}^2$ in the regressions for M^* and OWM^* (column 8).

Composition and Behavior of Inventories

For the durable goods sector of manufacturing, inventories of work in process have been, at least since 1953, consistently larger than those of materials and supplies, which in turn have been consistently larger than those of finished goods. These facts reflect the distribution of inventories in the large part of this sector where production to order is very important; in the more stock-oriented part, the proportion of finished goods in the inventories was much greater.[73] For the nondurable goods sector, goods-in-process stocks are the smallest; finished goods added up to smaller values than materials and supplies in the fifties but rose to exceed them in the sixties. Again, as is expected, the high proportion of finished goods is due to that large part of this sector representing manufacture to stock. For other component nondurable goods industries, the weight of finished stocks is considerably smaller.[74]

In short, there are strong indications that inventories in those industries that produce largely to order consist principally of materials and work in process, while in industries that produce mainly to stock a much larger proportion of the inventory is in finished form. It can also be said that the former industries account for a major part of total manufacturers' inventories of materials and goods in process, while the latter industries account for the bulk of total manufacturers' inventories of finished goods.

These findings confirm the argument that the finished stocks of goods made to order should be small, since such goods are usually shipped promptly. Accordingly, materials and goods in process ought to make up the bulk of inventories in industries that produce largely to order. The purpose of these stocks is to keep the delivery periods for the products into which they are processed competitively short. In production

[73] Finished stocks were particularly small relative to either of the other categories in the transportation equipment industry, due only in part to the prevalence of production to order in the nonautomotive division of this industry, since large inventories of cars are held by dealers. But finished stocks were also much smaller than materials stocks in primary metals and much smaller than work-in-process stocks in machinery. On the other hand, finished stocks were larger than either the materials or the in-process stocks in the stone, clay, and glass products industry, and they were not consistently smaller than either in the combined remaining durable goods industries. For evidence, see U.S. Department of Commerce, Bureau of the Census, *Chart Book, Manufacturers' Shipments, Inventories, and Orders: 1953–1963 Revised,* Supplement, Washington, D.C., 1964, Charts 98 and 100–104, pp. 99, 101–105.

[74] In chemicals, petroleum and coal, and rubber and plastic products, finished stocks are definitely dominant, but in the group of all other nondurable goods industries, where the weight of production to order is greater, materials stocks exceed finished stocks. See *ibid.,* Charts 99 and 105–108, pp. 100, 106–109.

to stock, where immediate delivery is expected, this can be accomplished only by holding adequate inventories of *finished* goods.

These results yield some interesting implications on the plausible assumption that the behavior of an aggregate series for inventory or inventory investment depends on the composition of the aggregate. One expectation is that changes in the demand indicators for industries engaged in production to order should have important direct effects on the stocks of goods in process as well as on those of purchased materials. On the other hand, changes in unfilled orders should have no such effects on finished-goods inventories in the same industries.

The similarity of movements in aggregate purchased-materials and goods-in-process inventories has been recognized in regression studies that combine the two categories into one aggregate or treat them separately but use nearly the same specification for each.[75] However, these approaches disregard important differences that are revealed through disaggregation by both industry and stage of fabrication. For an industry producing to order, investment in goods in process has been shown to depend positively on lagged values of orders received but negatively on current shipments (Table 8-4, second line). This result at first seems puzzling. It is attributable to production processes that typically take a long time to complete and are presumably also discontinuous.[76] The net impact of current shipments on investment in goods in process was also found to be negative for the motor vehicles sector, where output consists largely of standardized mass-produced goods but the production processes are classified as predominantly discontinuous. In other industries that work largely to stock, the estimated effects of

[75] In Lovell's equations, materials and goods in process are combined (see Table 8-3, first three lines). The estimates by Smith and Paradiso in Joint Economic Committee, *Inventory Fluctuations*, Part 1, are based on separate regressions for each stage of fabrication, all of which include sales and the change in unfilled orders for the preceding quarter, as well as a lagged stock variable.

[76] Following Abramovitz, *Inventories*, pp. 160–71, stocks of goods in process can be classified into those held between and those held within stages of manufacture. In some industries, production processes are discontinuous, i.e., they combine two or more operations of making and assembling parts into a finished product, and firms can store semifinished goods between such operations or "stages." Production increases may then be accompanied by a conversion of some of these stocks into actively processed "within-stage" stocks, instead of requiring prompt and commensurate increases in total work-in-process inventories. In other industries, however, keeping surplus stocks of partly fabricated goods between stages may be either technically impossible or economically impractical, because of the prevalence of continuous (single- or multistage) processes. The proportions of aggregate inventories accounted for by the discontinuous-process industries are apparently substantial in most divisions of durable goods manufacturing, and especially for machinery and transportation equipment (see Abramovitz, *Inventories*, App. D, pp. 557–60, and Stanback, *Postwar Cycles*, pp. 96–97).

shipments are on balance positive. The new orders and backlog variables have generally positive and significant coefficients. These results appear broadly consistent with, and supplementary to, the conclusions of the studies of cyclical behavior of inventories by Abramovitz and Stanback.

Also interesting in this context is the sluggishness of finished-goods inventories, shown in the lower panel of Chart 8-4.[77] It is clear, particularly for the durables, that these aggregates tend to lag, i.e., continue to rise in the first half of contraction and to decline in the initial stage of expansion. Furthermore, stocks of finished goods tend to lag behind the other inventory investment series. Product inventories also typically continue to increase (decrease) well after the downturn (upturn) in shipments.[78]

The lags and the corresponding inverted movements in these comprehensive series can be traced to staple, nonperishable, made-to-stock goods whose production fluctuates mainly with changes in demand. The cyclical movement that is characteristic of a sample of inventory investment series for commodities in this class resembles quite well the movement observed for aggregate finished-goods investment.[79] To the extent that the inventories of these goods rise (fall) with the irregularly timed decreases (increases) in sales, they act as short-period "buffers," i.e., output stabilizers.

In accordance with these considerations, one finds that finished-goods inventories of industries working predominantly to stock, e.g., chemicals and allied products and stone, clay, and glass products, show much the same trends and cyclical fluctuations as shipments, allowing for the definitely lagging and smoother time-path of the inventories.[80] Similar, although somewhat less regular, associations are observed between the comprehensive series. In the nondurable goods sector, finished stocks followed shipments at each major turn of the period 1948–61, with lags averaging eight months. In the durable goods sector, the behavior of product inventories shows similar conformity and slug-

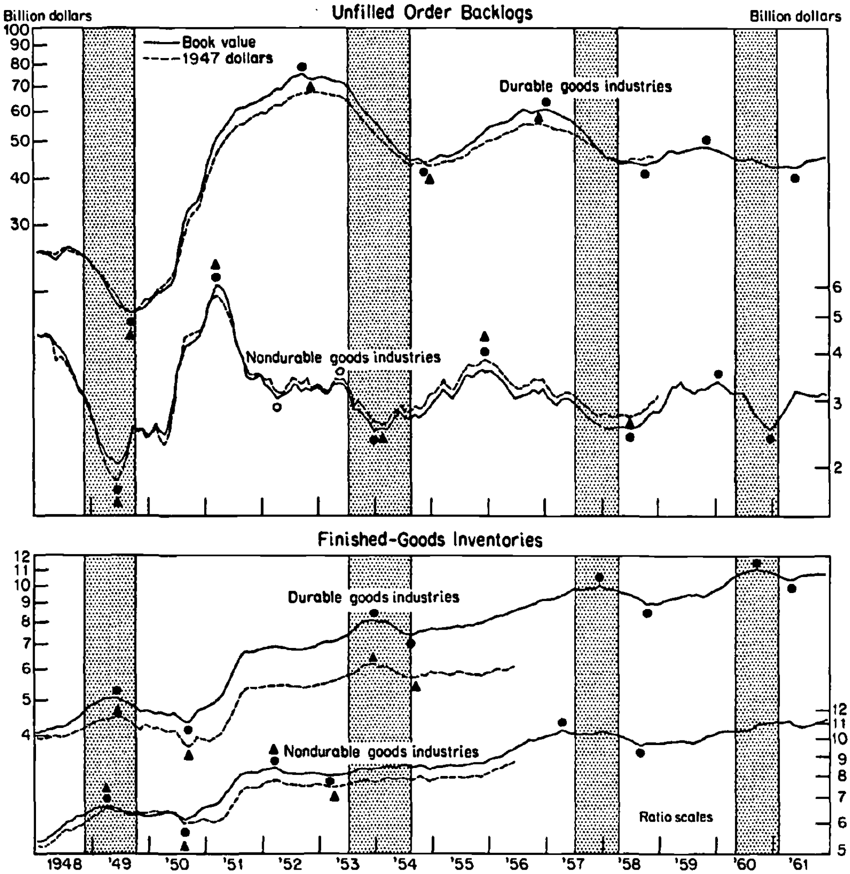
[77] The inventory series in book value are Department of Commerce end-of-month estimates. The deflated series, in 1947 prices, have been compiled by Thomas Stanback and are available through mid-1956 (see Stanback, *Postwar Cycles*, App. B).

[78] For evidence, see *ibid.*, Chap. 5, with reference to Abramovitz's earlier work.

[79] See *ibid.*, pp. 74–75.

[80] This is evident from the graphs in Census, *Chart Book*, pp. 14, 41, 101, and 106.

Chart 8-4
Unfilled Order Backlogs and Finished-Goods Inventories in Current and Constant Prices, Durable and Nondurable Goods Industries, 1948–61



Note: Shaded areas represent business cycle contractions; unshaded areas, expansions. Triangles identify peaks and troughs in the deflated series; dots, undeflated series; circles, retardations.

Source: See note 76, in this chapter.

gishness (the average lag is about six months), with a little less consistency.[81]

I conclude that there is little doubt about the dominant role of unsold made-to-stock products in the recorded cyclical fluctuations of the finished-inventory series, and about the dependence of the latter on past values of shipments, as incorporated in many regression studies. The evidence suggests that the adjustments of finished stocks are as a rule partial and gradual, and at times too slow to prevent inverse and probably unintended movements. This may be due to predictive errors, inertia, high costs of abrupt and large changes in production rates, or some combinations of these factors.

While finished stocks are larger for the nondurables than for durables and most of the time behave similarly in the two sectors, backlogs of unfilled orders are far smaller for the nondurables than for durables and often behave very differently in the two sectors. To show these contrasts, Chart 8-4 includes, in the upper panel, the unfilled orders aggregates for both the durable and nondurable goods industries.[82] The marked differences between the series in the two panels may serve as a reminder that there is no ground for expecting finished goods to have the type of relationship with unfilled order backlogs that can be expected for purchased materials and probably also to a large extent for goods in process. Finished inventories and unfilled orders of manufacturers differ drastically in their composition. In 1954, for example, 41.9 per cent of total manufacturers' backlogs were held by the transportation equipment industry and 5.9 per cent by the entire nondurables sector; the corresponding shares in total finished-goods stocks were 6.0 per cent for transportation equipment and 52.8 per cent for nondurables. There is no simple cause-and-effect or mutual-dependence relation between the heterogeneous industry aggregates involved.

[81] The last two sentences of the text refer to the inventory series shown in Chart 8-4 for 1948–61 and to the corresponding value-of-shipments series in Chart 3-3.

[82] The deflated backlog series are calculated by cumulation of monthly differences between new orders and shipments expressed in constant (average 1947–49) prices, starting from the initial levels of unfilled orders in 1948. The differences due to the adjustments for price changes are, on the whole, not large.

Summary

Materials are acquired to be used in production; hence, their stock depends on the demand for output. Changes in purchase orders for materials express reactions of the purchasing firms to the changes in sales orders received by them. Stocks on hand and stocks on order perform closely related functions, and their sum, the total "ownership" of materials, represents a meaningful decision variable.

Buying for inventory may be significantly influenced by supply conditions. Expectations of higher prices and longer delivery lags, for example, can be destabilizing if they cause intensified ordering ahead; rises in suppliers' backlogs would then both signalize such a development and result from it. In time, however, increases of prices and delivery periods will likely begin to deter buying, and competition among suppliers will tend to counteract such increases.

Firms that accumulate unfilled orders for their products have a growing amount of business in hand and are expected to increase their buying of materials. Since the orders backlog represents future sales, this hypothesis is really an extension of the general accelerator concept of the inventory-sales relationship.

Stocks of materials increase through deliveries on purchase orders and decrease through transformation into stocks of goods in process, which in turn decrease through transformation into finished-goods stocks. Where the production processes are sufficiently long and responsive to past orders, it is possible to distinguish between the inflow and outflow factors in estimating inventories classified by stage of fabrication. Where the processes are typically short, as in many industries working to stock, such distinctions are not operational.

In production to stock, unintended changes in inventories of finished goods occur because of errors in sales forecasts. In production to order, which follows revealed rather than anticipated demand, this component of inventory investment is of minor or no importance. Inventories of products made to order consist of presold goods in transit, and their changes are largely random, apart from any long-term trends reflecting the industry's growth or the like.

The analysis indicates that one should expect inventory behavior to show systematic differences both between stages of fabrication and between industries producing mainly to stock and industries producing mainly to order. A review of literature brings out evidence that is generally consistent with this position but is rather severely limited by (1) frequent neglect of the required distinctions and (2) inadequacy of the data.

Census series for the period since 1953 permit the construction of estimates of outstanding purchase orders for materials (*OUM*). Quarterly regressions show *OUM* to be positively associated with the previous values of new and unfilled orders of all manufacturers and with the change in the price index for materials, and negatively associated with the lagged interest rate on short-term bank loans to business. These signs of the estimated coefficients agree with expectations. Purchased-material inventories (*M*) are less sensitive than *OUM* to changes in demand (the lagged order variables). The results are consistent with the view that firms can and do adjust their orders for materials considerably better than their inventories of materials. Typically, *OUM* are larger than *M* and have cyclical fluctuations of greater amplitude and earlier timing. The adjustments of *M* and, particularly, *OUM* toward desired levels do not involve very long lags. (Some recent studies of inventory behavior produced estimates that imply rather implausibly sluggish adjustments.)

Postwar data are in accord with expectations in indicating that inventories in those industries that produce largely to order consist principally of materials and goods in process, while inventories in industries that produce mainly to stock are held in much larger proportions in finished form. Stocks of finished goods tend to lag behind materials and work in process, and also behind shipments. These lags are attributable to nonperishable made-to-stock goods, which constitute the largest component category of finished stocks.