1. Gaps in the Explanation of Inventory Behavior

Inventories are a form of productive capital and as such their size must depend on the work that they are expected to perform. Viewed at an omnibus level, this work depends on the size of the vast aggregates of goods that churn through the factories and stores of the country. But viewed from within those factories and stores, many things in addition to the volume of goods that are to be processed and shipped determine the appropriate size of stocks; these include expectations about prices and other conditions in the markets in which materials are bought and finished products sold, availability and cost of funds with which to finance stocks, and all sorts of other things that influence the cost of holding stock relative to the cost of coping in some other way with the managerial objectives that stocks serve.

The many considerations that govern the size that stocks ought to be are, like virtually all determinants of economic behavior, expectations rather than precisely current, precisely known circumstances. Expectations typically diverge in some respect from reality as it unfolds. These divergences, too, govern the size of stock at a given time. Actions governing stock, then, depend on a web of expectations. The behavior of stock depends also on how expectations match the reality that comes to pass.

But expectations depend heavily on information; this is self-evident if economic behavior is "intendedly rational." In consequence, a fruitful study of the behavior of inventories must make a determined effort to admit information to full view and concern. In this sense the investigator copies the decision maker.

Just how to achieve this ambitious objective is hard indeed to say; the study struggles with it at every turn. However, one approach is clearly indicated: orders that are received and placed by business enterprises, and the portion of each that remains unfilled at any given time, constitute an important form and source of information. In addition, unfilled orders change the actual conditions under which stock-carrying decisions are made. Outstanding orders for materials afford a secondary reserve of materials flowing toward the sales end of a production chain. Unfilled orders for the product a company sells—order backlogs—influence the risk involved in buying materials farther ahead than usual, and thus the advantage in holding materials stocks on hand or on order. At very least, then, it is essential to come to grips with the question of how to deal with the relation between orders, unfilled orders, and stocks in a meaningful way in the context of business fluctuation.

These impressions point to questions that have concerned economists for some time. The inability of the sales-stock relation alone to explain inventory behavior, and the value of unfilled orders as an assistant in doing so, are ideas that are not at variance with the direction in which the empirical study of inventories has moved in recent years. Without attempting to be systematic, it will be useful to highlight some of the major developments of this line of thought and also to point to some of the unanswered questions to which it gives rise.

THE INFLUENCE OF SALES

The point of departure for empirical analysis was a theory which explained inventory investment in terms of a constant desired association between demand and inventories. J. M. Clark, in his classic formulation of "the law of demand for intermediate products," focused on this underlying association and its prolific implications.[1] The Lundberg-Metzler formulation went on to show how the way in which expectations could be formulated, and the backwash of inevitable error on subsequent events, flouted the achievement of intentions.[2] Nevertheless he formulated desired inventory in terms of a fixed average (and he added an alternative, incremental) association with expected output.

As counterpoint to this elegant theme, empirical examination of the evidence felt its way. Moses Abramovitz' pioneer work with the scant data of the interwar years revealed a lag between change in inventories and change in output. The lag itself did not controvert the theory, but the irregularity of the association was troublesome, and Abramovitz attributed it to the different behavior and different relative importance, at various stages of the cycles, of the three levels of inventories: finished, in-process, and "raw" goods.[3]

Thomas Stanback, inspecting the richer materials of the postwar years, also found wide variations in the behavior of change in sales and change in stock.[4]

The extent to which inventories fail to be explained by their association to sales can be summarized by annual ratios of change in output to change in stocks, in constant prices.[5] Sales during the year are compared with stocks at the end of the year to allow for the lag previously discussed.[6] The calculations indicate that stocks changed in the same direction as sales in all but two of the years from 1930 to 1953 (omitting 1942 to 1945). The positive ratios ranged from 0.7 to 20.7; the average was 6.4 and the average deviation

[1] J. M. Clark, "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles," *Journal of Political Economy,* March 1917, pp. 217–235.

[2] Lloyd A. Metzler, "The Nature and Stability of Inventory Cycles," *Review of Economics and Statistics,* August 1941, pp. 113–129. Metzler credits Carl Lundberg with the conception of the model that he develops.

[3] Moses Abramovitz, *Inventories and Business Cycles, with Special Reference to Manufacturers' Inventories,* New York, NBER, 1950. The extent of the difference in the behavior of the two aggregates is interesting: "The rate of growth in output reaches a high point considerably before the end of expansion, a trough considerably before the end of contraction" (p. 378). This may be followed by a period of retarded change and sometimes an additional minor movement: "The movements of inventory investment are quite different. The rate of accumulation of inventories is typically low—usually negative—at the beginning of expansion. And whatever oscillations it may experience during the course of the phase—annual data do not give any indication of serious intra-phase fluctuations—it normally reaches its peak near the peak of the business cycle" (p. 378).

[4] Thomas M. Stanback, Jr., *Postwar Cycles in Manufacturers' Inventories,* New York, NBER, 1962. See particularly Table 36, p. 117. The timing comparisons were quarter to quarter; the most inclusive data were changes in final purchases (less services) and nonfarm inventory investment; stocks of manufacturers, wholesalers, and retailers were also each compared with the relevant output series. The distribution of timing comparisons was as follows:

Inventory Investment Compared to Change in Sales, Quarters (Q)	*Inclusive Series*	*Three Other Series*
Unmatched	2	4
Lead 1 Q	3	1
Lead 3 Q	0	1
Synchronous	2	3
Lag 1 Q	1	8
Lag 2 or 3 Q	2	10
Lag 4 or 5 Q		3
Total series turns	10	30

[5] Cf. R. P. Mack, comment to a paper by Franco Modigliani, "Business Reasons for Holding Inventories and Their Macro-Economic Implications," in *Problems of Capital Formation: Concepts, Measurement, and Controlling Factors,* Studies in Income and Wealth 19, Princeton University Press for NBER, 1957, p. 509.

[6] The lag implicit in using stocks at the end of the year appears to give the most stable ratios. The incremental ratio reduces the substantial cyclical fluctuation that characterizes the average ratio.

was ±5.3. The implications of this wide variation in terms of the power of sales to determine inventory investment may be brought out if actual year-to-year changes in stocks are compared with what they would have been had the incremental sales-stock ratio been constant at the median value. Average actual change was \$3.6 billion; the *error* of estimating change on the basis of the constant ratio was ±\$2.6 billion—72 per cent of the actual change.

Obviously, then, in order to understand the behavior of stocks, influences in addition to a presumed constant association to sales must be sought. Increasingly, in the past two decades, econometric analysis has been brought to bear on this difficult task. Different investigators have made different calculations based on different theories.[7] But recurring in recent studies are two themes which bear particularly on the general problem of meaningful analysis of the role of inventory fluctuation. One is the inclusion of unfilled orders as an explanatory variable, the other the use of distributed lags.

THE INFLUENCE OF UNFILLED ORDERS

The work of several analysts has shown that unfilled orders help to explain inventory investment. Unfilled orders must have at least some bearing on the changing expectations about market conditions on which this monograph focuses. But the difficulty with the findings of a number of studies that I would like to discuss is that unfilled orders are *too* helpful.[8] Simple correlation coefficients relating change in unfilled orders to change in variously defined stock aggregates ranged, for two investigations, from .82 to .84.[9] Beta coefficients indicate that the explanatory power of unfilled orders is roughly at a par with sales. But the actual statistics used to represent unfilled orders are heavily dominated by backlogs of sales orders in the machinery and transportation equipment industries, which on the average contribute 70 per cent of the total.[10] It is difficult to see why unfilled sales orders in these two industries should so heavily influence stock for all manufacturers (plus distributors in one investigation).

As to the explanation of the role of unfilled orders, the several investigators partly agree and partly differ.[11] Darling emphasizes

[7] For a summary and analysis of a large number of studies, see a very interesting article by Michael Lovell, "Determinants of Inventory Investment," in *Models of Income Determination,* Studies in Income and Wealth 28, Princeton for NBER, 1964.

[8] The basic references in which the work here discussed appears are: (1) Paul G. Darling, "Manufacturers' Inventory Investment, 1947–1958," *American Economic Review,* December 1959, pp. 950–963, and (2) Darling, "Inventory Fluctuations and Economic Instability: An Analysis Based on the Post War Economy," Joint Economic Committee, *Inventory Fluctuations and Economic Stabilization,* Washington, 1961, Part III; (3) Michael C. Lovell, "Factors Determining Manufacturing Inventory Investment," *Inventory Fluctuations and Economic Stabilization,* Part II, (4) Lovell, "Buffer Stocks, Sales Expectations, and Stability: A Multi-Sector Analysis of the Inventory Cycle," *Econometrica,* April 1962, and (5) Lovell, "Manufacturers' Inventories, Sales Expectations, and the Acceleration Principle," *Inventory Fluctuations and Economic Stabilization,* Part II (reprinted from *Econometrica,* July 1961); (6) Nestor E. Terleckyj, *Measures of Inventory Conditions,* National Industrial Conference Board Technical Paper 8, New York, 1960 (reprinted in *Inventory Fluctuations and Economic Stabilization,* Part II); (7) Lovell, "Determinants of Inventory Investment" (see footnote 7), and (8) Ruth P. Mack, comment on the preceding paper (*ibid.,* pp. 224–231); this comment is the direct source of most of the discussion of the next several pages.

[9] See note 8, references 1 and 3, and reference 8 (pp. 225–226).

[10] The figures are given in Ruth P. Mack, "Changes in Ownership of Purchased Materials," *Inventory Fluctuations and Economic Stabilization,* Part II, p. 86, note 8.

[11] Darling: ". . . inventory investment is more closely associated in time with receipt of the order, or more accurately with changes in the 'unfilled order' backlog, than with the delivery (sale) of the goods to the buyers. Indeed, the sale is an act of *dis*investment rather than a determinant of investment in stocks"

two causal influences: firms buy when they sell (when customers place orders), not when they ship; buffer stocks need to be greater when supply conditions tighten, which tends to be when the rate of change in backlogs is greatest. Lovell attributes the positive association primarily to the fact that an increase in backlogs anticipates an increase in production, which dictates an increase in stock. He agrees with Darling's first reason insofar as he thinks firms like to buy when they sell, as a hedge against shortages or price change. Terleckyj agrees with Lovell's first reason concerning the relevance of the link between backlogs and production.

The influence of unfilled orders on stocks has also been observed in time series without benefit of econometric analysis. To mention only one example, Stanback has displayed the impressive parallelism among stocks of purchased materials, new orders, and series that reflect the speed with which materials are delivered and the delivery terms on which purchasing agents buy.[12] These in turn are closely similar to unfilled orders.[13] His explanation is complex, but he seems to emphasize the changing supply conditions that these figures feature—conditions that may be based on limitations imposed by plant capacity: "The influence of supply conditions may operate in two ways during expansions: (1) deterioration in supply conditions makes it more difficult to achieve inventory objectives, and the realized inventory investment will be somewhat less than that desired; and (2) deterioration in supply conditions influences the inventory objective itself." [14]

These studies indicate, then, that inventory investment is, roughly, equally influenced by unfilled orders and sales. At the same time, the explanations proffered do not develop agreement on the reasons why this should be so, particularly in view of the lopsided industrial composition of the statistics themselves.

UNEXPLAINED CHANGE

The problem is further complicated by what the equations fail to explain. When the time series themselves are compared, stock typically lags sales or output. The lagged association is given an interesting interpretation by Richard Goodwin's notion of the "flexible accelerator": firms typically attempt only a partial adjustment of inventory toward its

(note 8, reference 2, p. 30). To the selling firm, unfilled orders give rise to "pipeline" stocks. Also, because of competitive pressures in supplying markets, "the time of greatest uncertainty for purchasing firms during business expansions, and hence the period in which their need for buffer stocks will be greatest, will tend to coincide with the period during which the *rate of increase of unfilled orders is at a peak.*" Accordingly, changes in unfilled orders are introduced to take account of "buffer stock" reactions to actual and expected conditions in markets, specifically, changes in delivery period and in the reliability of quoted delivery dates (*ibid.*, p. 33).

Lovell: "If unfilled orders represent an established demand, indeed a possible committal to deliver at some future date, entrepreneurs may well consider it advisable to carry additional stocks when unfilled orders are large as a hedge against possible shortage and price commitments. In addition, a rise in the backlog of unfilled orders may be expected to lead to an acceleration of production that is felt first in terms of an increase of goods in process rather than a rise in the output of completed commodities" (note 8, reference 3, pp. 140–141). Lovell seems to disagree with Darling's second reason: "Conversely, if unfilled orders were only a surrogate measure for the tightness of the markets on which firms purchase their inputs, a negative relationship between orders and stocks would be revealed . . ." (*ibid.*, p. 141).

Terleckyj: "One would expect that when new orders are running above sales, and the reservoir of future business is built up, an accumulation of inventories becomes desirable, as the planned production rate rises to fill these orders. The subsequent increase in the actual production rate entails a rise in inventories concentrated in the in-process stocks" (note 8, reference 6, p. 21).

[12] Stanback, *Postwar Cycles*, Chart 9, p. 55.

[13] *Ibid.*, p. 50.

[14] *Ibid.*, p. 58.

equilibrium level in each period.[15] When this construction is used, there is an equilibrium level of stock—one which firms would not want to change, once achieved—and this differs from the actual level.

Michael Lovell reviewed a number of postwar studies and calculated equilibrium levels of stock, and what they imply about the extent to which firms attempt to adjust inventories to that level in a single period.[16] If complete adjustment were achieved, the "reaction coefficient" would be 1, but for two equations [17] for which the coefficient could be calculated it was about one-half for an entire year or about one-fifth a quarter, ". . . implying that firms in manufacturing attempt to liquidate roughly one-fifth of the discrepancy between equilibrium and actual inventories each quarter." [18] For his own effort to explain nonfarm inventory investment, 1947–59, in terms of gross national product, its rate of change, and unfilled orders, Lovell calculated differences between equilibrium and estimated (or actual) inventories quarter by quarter. These "surplus inventories" averaged substantially larger than the quarter-to-quarter change in actual inventories, $1.7 billion compared to $1.0 billion, ignoring signs in both cases.[19] They tended to move in opposite directions, being negative when investment is positive and vice versa.

What, one is moved to ask, is the meaning of a business objective which is only one-fifth achieved in the course of three months, or one which results in nonintended stocks substantially larger than the total change in stocks? At the least, "passive" inventory investment must be very large—far larger than seems to make sense. Random disturbances and mistakes also may be partly responsible.

In any event, very much a part of the picture are the assumptions, embodied in the equation, concerning the requirements which when satisfied produce equilibrium stock. If unfilled orders [20] and demand do not in fact largely determine inventory investment, then "equilibrium stock," defined in terms of the two variables, will not, except by chance, be achieved. How realistic are the assumptions? How, in fact, is inventory investment usually determined? The next chapter aims to take some tentative steps toward an answer by looking at the business firm itself.

[15] 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.

[16] Note 8, reference 7.

[17] The studies were by Lawrence A. Klein, who used annual data, 1921–41, for which the reaction coefficient as calculated by Lovell was .5. (Lawrence R. Klein, *Economic Fluctuations in the United States, 1921–41,* Cowles Commission Monograph 11, New York, 1950); and Darling, note 8, reference 1, pp. 5–6; cf. Lovell, note 8, reference 7, pp. 183–184, and Mack, reference 8, p. 226.

[18] Lovell, note 7, p. 184.

[19] Lovell, note 8, reference 7, p. 187. I summed the figures only through 1959, since the last two years were extrapolations.

[20] Klein's equation uses wholesale prices rather than unfilled orders.