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BUSINESS REASONS FOR HOLDING INVENTORIES AND THEIR MACRO-ECONOMIC IMPLICATIONS

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Among the most significant developments in business cycle theory in recent years have been the contributions to the theory of the inventory cycle by Lloyd A. Metzler and others. By[1] combining the basic tools of Keynesian macro-economic analysis with the hypothesis of an "optimum" or "desirable" relation which firms endeavor to maintain between inventories and sales, these studies have given us a plausible picture of why and how economic activity tends to react with a cyclical pattern to an initial disturbance in aggregate demand.

These studies, however, have typically rested on an aggregative type of analysis and have not been too much concerned with exploring the micro-economic justifications for the assumption of a "desired" stock-sales relation. It seems therefore appropriate to ask whether this assumption, which plays an important role in the above-mentioned models, can in fact be defended on the basis of a close examination of the role of inventories in the economics of the firm. The main purpose of this paper is to attempt to answer to this question, which has been sharply raised by Ruth P. Mack in her contribution to this volume and in her related paper, "The Process of Capital Formation in Inventories and the Vertical Propagation of Business Cycles."[2] Mack herself seems to be largely inclined to answer this question in the negative.

As will soon become apparent, in analyzing the issues involved I will be relying heavily on the contributions of another rapidly growing field of study which has been variously labeled as "engineering economics," "operations research," "management science," etc. As is well known, this field consists, broadly speaking, of the

Note: The present paper grows out of what was initially intended as a comment to Ruth P. Mack's contribution to this volume, "Characteristics of Inventory Investment: The Aggregate and Its Parts." However, it is presented as a separate paper primarily because it is not a criticism of Mack's analysis but rather an attempt to answer certain questions raised in her analysis and in a related contribution by her referred to in the text.

[1]See the references quoted in Ruth P. Mack's paper, footnote 12.

[2]*Review of Economics and Statistics*, August 1953.

application of analytical tools and the methods of statistical inference to the solution of operating problems faced by business firms and other organizations. These problems themselves revolve largely around a question with which the traditional economist has long been concerned, namely the question of how to get the most for the least. However, the traditional economist has been interested in these problems from a different point of view: in order to construct models of economic behavior (economic theory) or to evaluate the performance of a given set of institutions (welfare economics) rather than to advise individual firms or organizations. Since the contributors to this new area appear to have a strong attachment to one or the other of the various names mentioned earlier, I will try to avoid hurting anybody's feelings by making use of a yet different name, viz. "normative micro-economics."[3] This name is, I feel, no less impressive than the others, but, being more in line with the accepted nomenclature of the traditional areas of economics, it may help to convey more immediately the relation of the new field to those areas.

It happens that the problems of inventory management are among those with which normative micro-economics has been, and still is, particularly concerned.[4] In attempting to answer the question posed by Mack I will draw on the outcome of these investigations as well as on my own experience as a member of a research team presently working on problems of production scheduling and inventory control.[5]

It may be noted in passing that the growth of normative micro-economics has given rise to some heated discussions as to whether this new area can possibly contribute anything to the science of economics in the traditional sense and whether, therefore, it should be acknowledged at all as a branch of that science. Since in this note I draw on normative micro-economics to answer a macro-economic question, what follows may, perhaps, also throw some light on the issues of that controversy.

[3]"Micro-economics" in that it deals with individual units, such as firms; "normative" because, like welfare economics, it purports to give advice rather than to describe or explain behavior.

[4]For further information on some of these studies and some bibliographical references see, e.g. T. M. Whitin, "Inventory Control Research: a Survey," *Management Science*, October 1954.

[5]The research in question is part of a larger project, "The Planning and Control of Industrial Operations," under contract with the Office of Naval Research. The other members of the team are Herbert A. Simon and Charles C. Holt, whom I wish to thank for general advice and specific suggestions in connection with the preparation of this paper.

Before attacking the central problem, I should like to indulge in a brief critical comment on one aspect of Mack's contribution. Without contradicting her general suggestion that we pay more attention to the individual components of aggregate stocks, I believe that many of the distinctions she is advocating are more apt to confuse than to clarify a problem already complex enough. A specific example may help to make this point clear.

As part of her contention that the effect of a given change in inventories depends not only on the over-all size but also on its internal structure, Mack emphasizes the importance of distinguishing between intended and unintended changes in stocks. For, she argues, "the impact on business fluctuation of a given amount of inventory investment [differs] depending on whether it is intended [or] unintended" (see section 1). If an increase in inventories is unintended "of necessity ... the stimulating ... effect of actual inventory investment is reduced in proportion to the unintended portion of the change" (section 4).

The passages quoted appear to involve a confusion between the effect of *previous* changes in stocks on the *previous* level of activity and the effect on *future* activity. As far as the first effect is concerned, most economists—including presumably Mack—would agree that the past increase in inventories, representing an *addition* to the past level of production, will have helped to sustain the level of activity while it lasted; this is so regardless of whether the addition was wholly or partly unplanned. As for the effect of the accumulation on future levels of activity there is, it is true, no simple answer—but this is because past change in stocks is *largely irrelevant to future change* in activity. This change will tend to depend not on whether stocks went up or down (bygones are bygones, as economists are fond of saying) but on whether stocks are now high or low relative to expected sales—and whether sales themselves are expected to be higher or lower than in the previous period. And there is no reason to believe that either of these relevant factors need bear a systematic relation to the previous change in stocks per se. In the Metzler models we find, for instance, that increases in stocks are followed roughly as frequently by increases in output as by decreases. There is, of course, no harm in labeling those increases in stocks which are followed by declining activity as "unintended increases" and those which are followed by increasing activity as "intended increases"—but there is also no evident advantage to be gained from these tautologies. There is even less to be gained by saying, as Mack seems to be doing, that

there *is* indeed a relation between past changes in stocks and future changes in activity but that we must distinguish four types of such changes as follows:

1. Activity will go up
   a. *When stocks have increased* if sales are expected to rise and stocks are (relatively) short (intended increase); or
   b. *When stocks have decreased* if the expected behavior of sales and their relation to stocks is as above (unintended decrease).
2. Activity will go down
   a. *When stocks have increased* if sales are expected to decline and stocks are long (unintended increase); or
   b. *When stocks have decreased* if the expected behavior of sales and their relation to stocks is as above (intended decrease).

But clearly the above fourfold classification is nothing but a complicated and confusing way of saying that the future change in activity does not depend on past changes in stocks at all, as is evident from the fact that the italicized clauses, containing references to past changes in stocks, can be dropped with no meaningful consequence.

I come now to the main issue—whether there is sufficient ground for the macro-economic assumption of a desired stock-sales ratio. Mack's doubts on this point seem to stem primarily from her observation that "the appropriate size of stocks is affected by factors that do not focus directly on stocks but involve matters such as convenience in procurement, efficient flow of work or service to customers, and the expected prices of purchased materials" (section 4). I find myself in complete agreement with this interesting observation: if anything, I would go one step further and submit that very nearly all the decisions that finally result in the holding of stocks are really based on considerations other than the maintenance of a given relation between stocks and sales. I propose to argue, however, that in spite of all this—and abstracting from the effect of price expectations—it is probably still useful, for the purpose of aggregative analysis, to proceed as though firms tried in fact to maintain a stable relation (though not necessarily a constant ratio)[6] between stocks and sales.

[6]The assumption that the desired relation is one of proportionality is convenient (in that it simplifies the mathematics) but not essential for the models under consideration. On this point, see Lloyd A. Metzler, "Comment," *Conference on Business Cycles*, National Bureau of Economic Re-

In order to support this statement I propose to examine briefly four major factors that justify, i.e. make profitable, the holding of inventories.

Procurement Costs

A first important reason for holding stocks arises when there are economies of bulk procurement, i.e. when the cost per unit is a decreasing function of the number of units procured simultaneously. Such economies are extremely common whether the item is procured internally or through outside purchases; they may result, e.g., from the presence of fixed costs (costs of placing and processing orders, or setting up costs) or from quantity discounts in purchasing or transporting the item, etc. As a result of the declining cost per unit, it will be generally profitable (in the sense that it will reduce the cost of sales) to procure the item in lots, although this method of procurement will result in the holding of inventories. The average amount of such holdings per unit of time will depend on the size of the lot, the precise nature of the dependence being determined by the nature of the procurement and demand conditions. If, for instance, there were no lead time, i.e. if a lot could be procured instantaneously, and sales occurred at a constant rate, the stock on hand would fluctuate between a full lot and zero and the average amount held would represent half an "optimum" lot. But precisely because (1) the average stock is related to the lot size and (2) the holding of stocks is a source of costs (interest, spoilage, obsolescence, cost of storage facilities), there arise definite limits to the size of the optimum lot that it pays to procure even if the procurement cost per unit should fall indefinitely. Beyond a certain point the reduced cost per unit is more than offset by the increasing cost of storage. In fact it will be found that in general the optimum size of the lot, and therefore the optimum average amount of inventories, is related to the rate of sales and tends to increase with it. This conclusion is supported by the numerous "optimum lot size formulas" which have been worked out with mathematical techniques, but its common sense can readily be grasped without any need for higher mathematics.[7]

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search, 1951, pp. 325–333; T. Whitin, *Theory of Inventory Management*, Princeton University Press, 1953, Chap. 5; and Ragnar Nurkse, "The Cyclical Pattern of Inventory Investment," *Quarterly Journal of Economics*, August 1952.

[7]For a given rate of sales, the optimum lot is such that the marginal inventory cost of carrying a larger lot would *just* more than offset the marginal saving *per unit of time* from increasing the size of the lot. But

The "average stock" of which we have been speaking is the average of a given item *over time*. But clearly, when we deal with a large number of firms (or of products within a firm) whose cycles of orders occur at random, a stable relation between average stocks and sales for each individual item over time will tend to generate, for any given (constant) rate of sales, a stable relation between aggregate stocks and aggregate sales *at each point of time.*[8] It is interesting to note that this stable relation between (optimum) stocks and sales is not at all the result of a direct attempt on the part of the decision-maker to keep at all times in stock a certain number of weeks' supply of any given item. Quite the contrary, for any given item the stock-sales ratio will fluctuate continuously and only attain sporadically, and in transition, the average value. No direct significance attaches to this average ratio for each item which is purely a "statistical" result of decisions focusing not on this ratio but on cost minimization. Nonetheless, from the point of view of describing the behavior of broad aggregates, the result of the "procurement cost" motive is precisely the same *as though firms were in fact trying to maintain stocks at a certain optimum level varying with sales.*

It may be objected that these conclusions are based on mathematical formulas which firms may not know or apply. There is in fact evidence that some of these formulas are known and applied. However, this is beside the point, just as it is beside the point to say that the theory of monopoly does not apply to reality *because* entrepreneurs do not know what is meant by marginal cost and marginal revenue. One would not expect a hardware retailer, whether or not he ever heard of optimum lot size formulas, to order a single screw of some standard type whenever he sold one, although this would reduce his inventories, or to order power drills by the carload although this would reduce transportation costs per

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this marginal saving per unit of time is equal to the marginal saving per unit multiplied by the number of units demanded per unit of time. Hence if the rate of sales increases, the marginal saving per unit of time must increase and presently exceed the marginal inventory cost. Clearly, to re-establish the marginal conditions, the size of the lot will generally have to be increased.

[8]In other words the stability of the time series average of the components of the "ensemble" generates a stable cross-section ratio of total stocks to total sales, the ratio in question representing an average of the time series average for each component weighted by the contribution of each item to total sales. It will be noted that the process described is in the nature of an ergodic process, in which the cross-section average coincides with the phase average of each component of the "ensemble."

unit. In other words, if we are willing to assume that firms endeavor to follow procedures which keep costs down—and there is no real reason for questioning such a tendency—we may expect to find that in their quest for cost saving (which may partly consist in the imitation of more successful firms) they will behave in ways which are not very different from those we can deduce from our formulas.

Smoothing of Production

A second important reason for holding stocks is to be found where production occurs in a continuous process but the unit cost of production is an increasing function of the rate of production or of variations in the rate of production. Under the postulated conditions—and indications are that such conditions are again quite common—it will frequently be profitable to keep production relatively stable in spite of fluctuations in sales, although this will result in the accumulation of inventories during slack seasons to be followed by liquidation during peak seasons. The factors that tend to control the behavior of stocks under these conditions have been examined at some length in another paper.[9] The results of that analysis indicate that if the only source of variation in sales were the (constant) seasonal, then stocks on hand at any given point of the year, and average stocks during the year, would tend to bear a definite and stable relation to the rate of sales. They further indicate that this stable relation may be regarded as the equivalent of the "desired" or optimum relation hypothesized in the inventory cycle models, in the sense that whenever the actual relation between inventories and (expected) sales is below the optimum relation, production will be high relative to sales, and vice versa. In other words firms will tend to behave as though they were in fact trying to maintain the normal relation or to re-establish it, if disturbed by errors in sales expectations. But once more, this behavior is not the result of a direct endeavor to have on hand a certain number of months' sales but rather the indirect result of the quest for an economical pattern of production.

[9]Franco Modigliani and Owen H. Sauerlender, "Economic Expectations and Plans of Firms in Relation to Short-Term Forecasting," *Short-Term Economic Forecasting*, Studies in Income and Wealth, Volume Seventeen, Princeton University Press for National Bureau of Economic Research, 1955, pp. 261-361. See also Charles C. Holt, Franco Modigliani, and Herbert A. Simon, "Linear Decision Rules for Production and Employment Scheduling," *Managment Science*, October 1955.

Expected Changes in Prices

The above two reasons for holding stocks, it will be noted, are basically unrelated to uncertainty of future demand; they would arise even if the future course of demand over the relevant horizon were known with certainty. A third reason for holding stocks even under certainty and, it would seem, the only important remaining one,[10] is to be found in the expectation of forthcoming changes in prices. An increase (decrease) in the future price of a purchased item is equivalent to a negative (positive) storage cost amounting to the percentage rate of change of the price. Hence if prices are expected to rise at a rate sufficiently high to offset the normal storage cost, the cost of sales can be reduced by procuring now the quantity that will be required to satisfy the demand over some future span of time—the length of the span depending on storage costs and on the expected behavior of prices.[11] Here again the result will be the holding of stocks equal to a certain number of months' requirements even though the decision was not at all focused on this objective.

Uncertainty and Lead Time

Uncertainty about future demand has been frequently regarded as the only significant reason for holding stocks. As we have just seen, this position is definitely untenable. As a matter of fact, one can go one step further and argue that if any needed item could be procured instantaneously at no extra cost, uncertainty of demand would not per se explain the holding of stocks. It is only in the presence of lead time, i.e. when an interval of time (possibly of uncertain length) elapses between the ordering of an item and its delivery, that uncertainty of demand becomes a separate, and undoubtedly very important, reason for holding stocks. In order to avoid the undesirable consequences of inability to satisfy demand (interruptions in the production process, loss of potential profits, loss of customers' goodwill, etc.) it becomes economical to place

[10]See, however, footnote 13.

[11]If we denote by $p(T)$ the price expected to rule T units of time from the present, and by r_i the cost of carrying a dollar of inventory per unit of time, it is readily seen that it will pay to cover future requirements now, if and only if, $p(1) > p(0)\ (1 + r_i)$ and the number of time units for which requirements should be covered is given by that value of T such that $p\ (t) > p\ (0)\ (1 + r_i)^t$ for $t < T$, while $p(T + 1) < p(0)(1 + r_i)^{T+1}$. (The results given apply to the case where T varies discretely; similar conditions can be established if T varies continuously, or with different assumptions about the form of the inventory carrying costs.)

orders when the stock on hand (plus that already on order) is somewhat larger than the quantity that is regarded as most likely to be demanded over the lead time. As a result, by the time the order is filled there will still be, on the average, some inventory on hand—the so-called buffer stock. It is fairly clear, even without a rigorous mathematical argument, that the "optimum" buffer will generally tend to increase with the rate of sales; furthermore this buffer can be expressed, and frequently is, as a certain number of weeks' sales. Once more the avowed purpose of the decision-maker is not that of maintaining a certain constant relation between inventories and the rate of sales, but that of procuring efficiently and avoiding run-outs.[12] As a matter of fact the stock of any given item will fluctuate continuously over time between certain limits. The average optimum inventory, however—roughly half an optimum lot plus buffer—will again bear a definite relation to the rate of sales. The resulting aggregate behavior will be much the same as though firms were trying to establish and maintain at each point of time a certain relation between stocks and sales.[13]

We thus emerge from an analysis of the major reasons for holding stocks with the following conclusion. While the immediate goal of decisions affecting the size of stock is usually not that of maintaining the stock of any given item in a certain desirable relation with sales, yet, for the purpose of aggregative analysis it may not be a bad approximation to assume, as has been done in recent inventory models, that firms endeavor to establish and maintain such a relation—modified, however, by price expectations. While this relation may not be desired per se, it performs the same role as if it were desired; perhaps one might refer to it as a "dummy" or "quasidesired" relation.

[12]In some instances firms report carrying a buffer equal to a certain number of weeks' requirements in order to be able to continue to operate for such a length of time even if the flow of supplies dries up completely as a result of special circumstances, such as strikes. This motive for holding inventories may well be classified under the heading of (uncertain) lead time; its quantitative importance is hard to assess.

[13]One reason for holding stocks that does not readily find its place in our fourfold classification is where the item can be procured (advantageously) only at certain specified points or periods of time, e.g. nonstorable crops requiring further processing, seasonal goods. This situation is analogous to simple lead time in that orders placed are not filled instantaneously except possibly at the "appropriate" times. Here the quantity procured at each permissible point will tend to exceed the demand "expected" up to the next permissible point by a suitable buffer, and the average stock will be in the order of half the expected demand plus the buffer.

The reasoning leading to the conclusion stated in the previous paragraph, incidentally, may help to explain the apparently frequent reference to stock-sales ratios in business practice. Inasmuch as "optimal" individual production or procurement decisions imply a fairly definite relation between aggregate inventories and sales, the aggregate stock-sales relation becomes a useful short cut approximation or rule of thumb to determine whether correct individual decisions have been made and are being made. One might expect that such rules would tend to be used particularly by higher levels of management in judging the performance of, or in setting broad rules for, the operating levels of management. Being primarily concerned with an over-all view of the operations and with their financial aspects, these higher levels of management may tend to look at inventories as an aggregate which absorbs funds and must therefore be held down. Needless to say, rules of thumb frequently acquire, through repeated use, an independent status and become, to some extent, ends in themselves.

Returning to the problem of macro-economic relations, our analysis further indicates that the quasidesired relation between stocks and sales is such that the desirable amount of stocks will tend to increase with sales. Besides the rate of sales, the rate of utilization of capacity is also likely to exert some influence. For when utilization increases, lead times will tend to lengthen and become more uncertain—with a concomitant increase in desirable buffer stocks. Similarly there will tend to arise an added incentive to adopt patterns of production that smooth seasonal variations in sales, with a concomitant increase in "smoothing" stocks; indeed when demand is high relative to existing capacity, the accumulation of inventories in the slack season may become the only way of satisfying the over-all demand.

A third factor affecting the desired relation between stocks and sales, which has been much stressed in traditional economics, is represented by variations in the cost of money—or in the availability of funds—which affects the optimum amount of inventories through the (opportunity) cost of holding inventories.[14] While this

[14]The influence of the availability of funds on the optimum level of physical inventories reflects partly the fact that money itself is a commodity of which the firm must hold an "optimum inventory." Because of the serious penalty usually attached to running out of money when it is demanded, the firm must plan to hold on the average a safety buffer, i.e. an amount over and above the balance of most likely disbursements minus most likely receipts. With a given fixed stock of working capital, the optimum balance in distributing this stock between various physical in-

factor may have been overstressed, its significance cannot be dismissed, at least pending further evidence. Finally the desirable relation between stocks and sales may well undergo gradual changes over time as a result of merchandizing and technological change, changes in the composition of output, etc. Actually most of these inferences appear to stand up well against the historical record, although it is not possible to pursue this point further here.

In summary then, the macro-economic assumption of a desired stock-sales relation appears to receive support from our analysis of the role of inventories in the economics of the firm. At the same time it should be recognized that this relation might be subject to gradual changes over time and also to systematic short-run changes as a result of variations in the level of demand relative to capacity and accompanying changes in lead time, of price expectations, and possibly of variations in interest rates.

To be sure, the above analysis does not enable us to say just how precise the desired relation between stocks and sales might be or just how fast any deviations would tend to be corrected. In this connection Mack's notion of permissive versus intended, i.e. planned, changes in stock may well be useful, although I feel that she has rather blurred her useful concept by including under "permissive" or "passive" changes those changes in stocks that result from "business objectives that focus on other matters than the appropriate size of stocks . . ." (section 4). It seems more useful to regard the desirable level of stock as the level appropriate after taking into account all of the systematic reasons that justify the holding of inventories. Even so it is quite conceivable that the desirable relation between stocks and sales might take the form of a "band" rather than of a "line"; a permissive variation would then be one which leaves stocks within the acceptable band. I doubt that the band in question is so large that it cannot be usefully approximated by a line, especially when dealing with appropriately broad aggregates. Accordingly I would be inclined to replace the hypothesis of a band of indifference with the hypothesis

ventories and cash (or very liquid assets) may be obtained by making a charge for the use of money representing the internal opportunity cost, or marginal productivity, in all alternative uses. As long as the firm has access to outside funds at a stated "market" interest rate, the internal or opportunity cost will coincide with the market or external rate. In the presence of capital rationing, however, the external rate may be lower than the internal one and the movements of the external rate need not bear any close relation to those of the internal rate or opportunity cost of money, which is the relevant factor controlling the optimum physical stock-sales relation.

that the discrepancy between actual and desirable inventories tends to be corrected at a certain rate, which may itself depend on the magnitude of the discrepancy.[15] This formulation bears some similarity to Mack's hypothesis in that the magnitude of the adjustment per unit of time would depend on the "distance" between the actual and the desired relation and might therefore be negligible when this distance is sufficiently "small." Clearly this is an area in which further research can throw much useful light.

Another area for further investigation whose importance is highlighted by Mack's contribution is the whole area of expectations. The notion of a "desired" relation, whose usefulness I have tried to defend, applies to the relation between stocks and *expected* sales—not *past* sales. In the inventory models to which I have referred, expected sales have been assumed to equal, or at most to bear some mechanical relation to, past sales. This may well be less than satisfactory, as my own work in progress in this area seems to suggest. Much remains to be learned as to when, why, and how significantly expected sales may differ from past experience and what recent experience is relevant in this context. Equally vexing are the many questions connected with expectations of price changes. When are these expectations sufficiently definite to alter the normal desired relation between stocks and sales? In what kinds of business are such deviations likely to be too important to be safely neglected? And what generates these price expectations? Here are but some of the many empirical questions that remain to be answered—and the sooner the better.

COMMENT

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Franco Modigliani's paper raises a question of method rather than fact. I can detect little or no difference in the fundamentals of Modigliani's picture of "business reasons for holding inventories"

[15]The hypothesis rests on the consideration that production and procurement decisions are typically being made almost continuously and therefore the level of inventories may be made to move gradually in the desired direction without necessarily taking any very drastic and dramatic decisions; drastic ad hoc decisions may, however, take place when inventories are seriously out of line. For some attempts at measuring the "speed of adjustment" see also my joint paper with O. H. Sauerlender, quoted above. The role of the notion of speed of adjustment in relation to business cycle models is discussed more extensively in my comment to the paper of Bert G. Hickman, included in this volume.

and mine as drawn in my paper in this volume, in the article to which Modigliani refers, and in the study of the shoe, leather, hide sequence that is parent to both.

True, Modigliani's paper is written as if the factors that cause or result in a stable relation between inventories and output were, in his judgment, a great deal more important in the totality of influences and behavior bearing on stocks than they are in mine. But I think this difference lies in his presentation and summaries, not in his basic descriptions. Were Modigliani fully to assess the implications of the facts he cites as relevant, our picture of the real world of inventory investment would appear closely similar.

For one thing he distorts my position when, on page 497, he quotes a statement made in connection with one type of situation—one resulting in "passive" stock change—as my contention about stocks as a whole. I have been at some pains to indicate that the appropriate size of some stocks, especially those carried by retailers, *does* focus directly on stocks, and that stock of no sort can be permitted to range indefinitely wide of the level appropriate to the volume of business. On the other hand Modigliani's argument understates the implications of other factors that he as well as I believe influence the size of stocks. For example he discusses the impact of physical problems of procurement in a footnote (13); he fails to point out that the proper size of buffer stocks is a function of fluctuations in the length of delivery periods as well as of their average length (p. 503); he treats *Expected Changes in Prices* and ignores in the summary statement in the last sentence one aspect of his own argument which points out that the number of weeks' supply that it is desirable to carry will vary with the expected rate of change in prices. He couches the entire argument in terms of desired stock and thus further subdues the factors that pull away from a steady stock-sales relationship.

Our differences, then, do not lie in how business behavior is viewed, but elsewhere. Modigliani says "past change in stocks is *largely irrelevant to future change* in activity." He says that passages in my paper involve a confusion between "the effect of *previous* changes in stocks on the *previous* level of activity and the effect on *future* activity." But my remarks cannot be excused on the grounds of confusion. They constitute an assertion that past changes in stocks, viewed in an ex ante framework, are relevant to future changes in activity. Indeed when properly understood and analyzed, past changes in stocks help to foretell future changes in stocks and in activity in general.

But to serve this purpose, knowledge of total stock change alone will not suffice. It is necessary to know how parts of the total have changed—parts reacting to each major constellation of situations capable of causing different time patterns in stocks. It is necessary to understand the business motives that control these stocks and how they operate under actual business conditions. Obviously there is no end to knowledge of this sort. The end must be imposed; the question is where to impose it.

For the purpose of understanding the behavior of economic aggregates, Modigliani claims that it can be imposed at the point where the major influence—the desired link between stocks and the volume of output—is accounted for. The other factors that influence the behavior of stocks cause the desired relation between stocks and sales to take the form of a band rather than a line. But he says, "I doubt that the band in question is so large that it cannot be usefully approximated by a line, especially when dealing with appropriately broad aggregates."

It may be that a judgment of this sort underlies the previous objection to my interest in the behavior of stocks as an indicator of future activity. For if the relation is sharp—a line not a band—then future stocks are determined by future output and there is no need to try to extract the bearing of past changes in stocks on future activity.

In any event it is clear that the real difference in our evaluations lies in a judgment about the width of the band. More particularly, since I have no disagreement with Modigliani's basic description of how stocks change, our difference rests in an evaluation of the relevance of the width of the band to macro-economic analysis. Here again a distinction is necessary: I agree that the band may be approximated by a line (with minor modifications) in analysis of *long-term* trends in stocks. But in the analysis of *short-term* changes of a cyclical or subcyclical order, I differ sharply with the notion that the range may be ignored.

I base this judgment on two sorts of considerations. First, information about business objectives and actions indicate that stocks respond to influences the time patterns of which do not necessarily parallel output, although they may do so. An example is the influence of market expectations of many sorts, including expected change in prices.[1]

[1]For evidence in time series of the impact of these factors, see Ruth Mack, *Consumption and Business Fluctuations: A Case Study of the Shoe, Leather, Hide Sequence*, National Bureau of Economic Research, 1956, Chapters 12 and 14.

Second, time series actually show a wide short-term variation in average or incremental ratios between aggregate output and aggregate stocks. The instability of the ratio is evident in time series for gross national product and total stocks measured in dollars of constant purchasing power. Since we know that the ratio of total GNP to total stocks has a cyclical pattern, it is preferable to compare ratios for increments. Approximate constancy in these relationships is one fairly flexible way of defining stability (rather than constancy) in the ratios of output and stocks proper. To this end, change in GNP in constant prices from one year to the next may be compared with change in end-of-year stocks.[2] GNP and stocks change in the same direction in all but two years from 1930 through 1953, excluding the war years 1942–1945. But the positive ratios range from 20.7 to 0.7. The average for all ratios is +6.4 and their average deviation from the mean, ±5.3. To get an idea of what this range implies, I calculate change in stock by multiplying GNP by a constant incremental ratio—the median, +3.6. Comparing these hypothetical changes under a constant ratio with actual change year by year, we find that whereas actual annual changes averaged $3.6 billion, the *error* of estimating change on the basis of a constant incremental ratio averaged $2.6 billion. Apparently most of the actual change in stock remains unexplained after change associated with maintaining a constant incremental output-stock ratio has been taken into account. The unexplained portion would be still higher were quarterly figures used, and certainly the relationship for three-month periods is relevant to the analysis of cyclical or subcyclical fluctuation. I interpret these figures as throwing the burden of proof on anyone who claims that experience shows that output-stock relationships may be thought of as stable in the context of short-term macro-economic analysis.

If then the band is broad, not narrow, knowledge of the factors that cause changes in stocks must penetrate to the level of explaining the cause of divergence from a stable relation to output—objectives that link desired stocks to prices or other market tensions, to patterns of availability of goods, to the perception of error in unintended change and the manner in which it is reversed, or to the tolerance, at least for a while, of passive change.

[2]Moses Abramovitz's analysis raises a question as to whether this relationship might be more stable if change in stocks were lagged. Inspection of the two time series suggests that the most stable relationship for the period would apply to the comparison as stated in the text, which implies a short lag.

This last distinction, which involves the notion of passive stock change, I have discussed in the paper in this volume. Bert S. Hickman thinks that the distinction complicates more than it informs. We need, he says, to test the two hypotheses already enunciated—the stable output-stock relation and the price-expectation influence on stock—not dream up more hypotheses. But the two hypotheses are not in my judgment alternatives but supplements. What is more, and here is an aid in testing, their relative roles must differ for different sorts of stocks. Further, were their relevance tested for still other stocks—finished stocks of manufacturers, for example, or total stocks of those manufacturers holding most of their stocks in finished form—their influence would be largely denied. The reason is that these stocks are what I have called passive for wide margins of variation. True, as Hickman points out, their change, since it is comprehended in the over-all management plan, may properly be called intended. But an essential to the process of investigation is the making of fruitful distinctions. For these stocks the word intention does not describe the essence of the business situation as it does for stocks whose size is subjected to close and incessant management purview. Also, at any given time, change in these passive stocks is often in the opposite direction from intended change in other stockpiles.' Nevertheless it is not unintended in the sense that it will be promptly corrected, although it will often parallel unintended change in other stockpiles. The point is that stocks subject to passive change behave differently and for different reasons than when change is primarily either intended or unintended.

The behavior of all stocks is, in other words, an arithmetic sum of the behavior of a number of classes of stocks that respond to different influences in different proportions. Since the quantitative relations among the several classes is highly variable in the short run, a test put to the total can at best be a muddy test and at worst no test at all.

The particular point at issue here is whether the category of passive stock change is a useful distinction that can earn its keep —the cost of complication. Only the future can surely tell, for without much more study judgments are necessarily subjective. I have tried to argue for it. I might add that I believe the concept is important for the study of transmission of business fluctuation from one enterprise to another. Passive stocks are an insulating substance for a time, and we need to know more about where this substance is found, how much there is of it at each type of locale, and

the varying circumstances under which passive change becomes unintended and therefore reversed. Conceptual delineation is a prerequisite to investigation. Even at a glance it seems clear that the notion of passive stock-change helps to elucidate the behavior of stocks in 1931 and 1932, and it helps in understanding why retailers' stocks align with sales more promptly than manufacturers' stocks, or why finished-materials stocks behave so differently from stocks of purchased materials.

In short, if the concept helps to describe reality but confuses theory, the difficulty must lie with the theory not with the concept. For it does not follow that because it is a bad thing for a theory to be more complicated than necessary, it is a good thing for a theory to be less complicated than necessary. The question is what is necessary, and the answer concerns the critical facts that need to be explained. Strong simplification is prerequisite to useful thought and therefore all but the essential matters must be discarded. Nevertheless there is a minimum that must be comprehended. The minimum differs with the problem; the critical facts about inventories are one thing in the context of long-term trends and another in the context of short-term fluctuations. In any context the judgment as to which are the essential facts is based in part on empirical evidence. Study of the actual world also helps to delineate a theory sufficiently specific to aid in explaining the facts. I do not claim to have described properly, but I do claim that description of the order of complexity that I have undertaken is necessary to a good theory of inventories.

This is a personal judgment in part, and others may not share it. Starting with a desire for simplicity and generality, every investigator who wishes to explain how things happen (at the level at which explanation serves a useful purpose) is usually forced, often against his esthetic predilections, to admit complicating factors and to make complicating distinctions. These decisions to include or exclude constitute the investigator's central vision, his basic hefting of the problem with which he deals. The decisions must not be made carelessly or in response to some early enchantment.