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UNFILLED ORDERS, DELIVERY PERIODS, AND PRICE CHANGES

AN INDUSTRY whose unfilled orders continue for some time to expand, both absolutely and relative to shipments, may be assumed to be experiencing "excess demand" for at least a large proportion of its output. This suggests that price adjustments ought to be related to such systematic backlog movements. My primary concern will be with these short-term price adjustments to demand pressures. Why does excess demand in some industries result in an accumulation of unfilled orders and queuing of buyers instead of its being absorbed by price increases as in other industries?

Consideration of the problem requires an analysis of variable delivery periods. Following a general discussion of their role and a brief discussion of the data used, the major part of this chapter develops measures of the relations between price changes and changes in backlogs and delivery periods (the last are indirectly represented by the backlog-shipment ratios). The consistency of these measures with some of my theoretical arguments is examined. Also, the principal factors presumed to influence the relationships concerned are reviewed, and some additional evidence is presented.[1]

Economics of Variable Delivery Periods

Media and Models of Adjustments to Business Change

Rises and falls in demand, reflected in fluctuations in the volume of orders received at given prices, can be met by: (1) increases and de-

[1]This chapter utilizes, but also expands and elaborates upon, parts of my article, "Unfilled Orders, Price Changes, and Business Fluctuations," *Review of Economics and Statistics*, November 1962 (reprinted as Occasional Paper 84, New York, NBER, 1962).

creases in current output and/or price; (2) depletions and replenishments of the inventory of the product; and (3) accumulations and decumulations of the order backlog.

In the limiting case of instantaneous reactions (1), finished stock is always nil and so is the backlog. The smaller the flexibility of inputs (the steeper the rise in marginal costs), the more the shifts of demand are absorbed by price changes and the less by output changes. It is well known that the marginal calculus of cost and revenue assures, within this pure model relying on (1) only, a continuous or period-by-period maximization of profit; also, that the model excludes some of the basic ingredients of economic life—uncertainty, lags of adjustments, and cost of change as a function of size and frequency of change. In manufacturing, particularly, the importance of these elements is accentuated, since demand for many industrial products is highly volatile in the short run and subject to large and varying cyclical movements. Rapid and frequent fluctuations in production rates are undesirable, since they are a proximate cause of increased costs and reduced operational efficiency.[2] Thus, the interaction of demand and cost factors in an unstable and uncertain environment often favors the role of stocks and backlogs as adjustment instruments or shock absorbers.

The relative importance of these forms of adjustment depends in part on business conditions in the given industry. A model showing this strongly, and providing at the same time a sharp contrast to the pure model of price-output adjustments (1), would employ (2) and (3) in the following cyclical sequence. Assume that new orders move cyclically in such a way that their rate exceeds that of capacity production in the latter part of an expansion. Then, in the first part of the contraction in buying, the level of production is sustained by drawing upon the backlog of orders carried over from the expansion. As the backlog is exhausted and the contraction of new orders continues, production is supported by working up a surplus inventory of the product. During the first half of the subsequent buying expansion, that surplus finished stock is sold first (in addition to the current output); in the second half, a backlog of unfilled orders is again accumulated.

In making maximum use of (2) and (3), this cyclical model dispro-

[2] Changes in the output rate will be accompanied by changes in the size and/or the rate of utilization of the work force, which are expensive in various ways, for example, through terminal payments, training outlays, overtime premiums, idle time, and possible impairments of good labor relations, morale, or productivity.

portionately magnifies certain elements of reality. It implies that order backlogs originate only in a strong boom and disappear in a slump, and vice versa for finished stock. Although a tendency toward such behavior probably does exist for certain products, it is too weak to show up in the aggregates or even in the more narrowly defined series in our sample. The model also treats backlog and stock accumulations in a strictly parallel fashion, whereas in fact the two have some implications that are quite different. The risk that some of the unfilled orders may be canceled varies among industries and with business conditions but on the whole appears to be much less prevalent and much less effective or serious than risk associated with the accumulation of unsold finished stock. Needless to say, new orders do not behave in the neat symmetrical manner assumed in the model. Instead they are for the most part notoriously difficult to predict, and this uncertainty factor favors the use of (3) rather than (2). But, however important for cost considerations, production stabilization is presumably not itself the primary objective, as the pure model of (3) implies. It should thus be treated as a means subordinate to, not as a goal commensurate with, profit maximization.

Furthermore, the type of short-run response mechanism in use frequently depends upon certain structural industry or market characteristics. It is not only in the advanced stages of vigorous business expansions and in the early stages of contractions that backlogs of unfilled orders appear, since it is common practice for firms in many lines of manufacturing to produce in response to demand ("to order") rather than in anticipation of demand ("to stock"). Pure production to stock allows adjustments of current output, price, and stock, but obviously not of unfilled order backlogs. In pure production to order, price adjustments are available for a firm that can influence price. The rates of output reflect those of new orders, with lags; the greater the input flexibility, the closer the relationship. However, while the volume of output under contract is determined by past orders, the short-period rate of output is not, since it depends also on delivery dates, over which the producer often has considerable discretion. It is these delivery-period adjustments (and the closely associated backlog changes) that are potentially of great importance here, while the stock adjustments are, of course, not feasible.

Differentiation of Delivery Periods and Competition

Lead times allowed the supplier are a source of costs to the customer. As a rule, the longer and more variable the leads, the higher are these costs. In the absence of major imperfections in the market, therefore, a supplier whose deliveries lag behind those of other manufacturers of the same product would not be able to maintain his sales for long, assuming equality of other trade terms.

However, a buyer may agree to accept a longer delivery period in return for a price concession; and, correspondingly, a premium may be paid for a reduction in the delivery period. Except in the special model of a market in which prompt delivery is insisted upon as a standard of product quality, differences in the delivery periods are perfectly compatible with competitive equilibrium if they are compensated for by price differentials acceptable to the buyer and seller. Thus, given sufficient information, competition would tend to equalize not just the selling price but the price for the item with a given delivery period (as well as other terms of sale disregarded in this analysis); there would be no discrimination in terms of compensatory price and delivery period combinations.[3]

The above argument counters the notion that the very existence of unfilled order backlogs is proof of a noncompetitive industry structure.[4] Actually, order backlogs are no more necessarily a symptom of departures from competition than are product stocks. Empirical evidence supports this view. We have matched up a number of the average stock-backlog (Q/U) ratios with concentration data for the same industries. The available comparisons indicate that there is little difference in competitiveness between those that manufacture to order and

[3] It is true that differentiation by delivery period (like that by customer specification of the desired product characteristics, which is probably more important) would lead to a segmentation of markets; but the resulting markets need not be small, and they would often be closely connected. The expert knowledge of industrial purchasers reduces the possibility that sellers will promote *artificial* product differentiation in the markets for equipment and materials and is generally a force supporting competition.

[4] The following (from Murray Brown, "Ex Ante and Ex Post Data in Inventory Investment," *Journal of the American Statistical Association*, September 1961, p. 526) is a more radical statement of this position than others I have found but it is representative: "The unfilled order variable applies only to an oligopolistic or imperfectly competitive firm and cannot be interpreted as a proxy for future demand for a firm in perfect competition. To show this, assume an increase in demand facing an industry; if each firm chooses to add to its order books and not raise [its] price, the market price remains constant; this violates an assumption of perfect competition that no firm can influence price."

those that manufacture to stock.[5] However, these tests use indicators of average conditions over relatively extended periods of time. It is still important to consider the role of competition in the context of short-run *changes* in backlogs, delivery periods, and prices. This topic will be taken up later in this analysis.

Interaction of Changes in Delivery Period and Price

The preceding suggests that the quantity demanded of a product is likely to be a decreasing function of the length of the delivery period, given the price and other terms of sale. Also, the average cost of producing a certain output often depends positively on the delivery period; so producers may ask for price premiums in return for speedier delivery and allow price discounts on longer-term orders. Thus both the buyer and the seller have schedules of equivalent combinations of delivery period and price, the former for a given quantity demanded, the latter for a quantity supplied. In the market there is an equilibrium process of weighing and reconciling these preferences of buyers and sellers.

A theoretical analysis of some basic aspects of this situation is given in Appendix H. There, a simple criterion is defined for a choice by the firm of a unique profit-maximizing combination of price (p) and delivery period (k). The position is such that no alteration of p and k by the firm can increase profit because the associated changes in sales and costs would offset each other.[6]

[5] The concentration ratios are substantial or high for some of the goods made largely to order (e.g., steel barrels, sheet and strip, pig iron) and low for others (e.g., most types of machine tools). For products made primarily to stock, the ratios vary similarly from extremely high (e.g., electric bulbs) to low (e.g., hosiery, hardwood flooring). Low concentration here means that the four leading firms produce less than 40 per cent of the industry's shipments in dollars; high, that they produce more than 60 per cent; substantial, 40 to 60 per cent. (The observations are based on data given in *Concentration in American Industry,* Report of the Senate Subcommittee on Antitrust and Monopoly to the Committee on the Judiciary, 85th Cong., 1st sess., Washington, D.C., 1957.) The limitations of concentration ratios as measures of competitiveness are well known but so also is the fact that in general no better summary measures are available.

Examination of the data for major industries (where our criterion is the proportion of total value of shipments accounted for by component industries with high or low concentration ratios) leads to similar negative results. For example, the electrical machinery industry is much more concentrated than the nonelectrical, and the weight of production to order in it is almost certainly considerably lower (note the importance of standardized electrical appliances for household use). A similar situation is found in transportation equipment, where the automobile industry, which is working to stock, is far more concentrated than the rest of the group in which production to order predominates (aircraft, shipbuilding, railroad equipment).

[6] It is a "joint optimum" of p and k, graphically a point determined by two sets of indifference curves for each given quantity demanded and supplied. These sets consist of: (1) the pairs of k and p associated with each given volume of demand, according to the preferences of buyers; (2) the pairs of k and c (average costs) associated with each given volume of supply, as seen by the producer-seller. See Appendix H, Figure H-1, and related text.

Changes in demand or the cost function or both would shift the equilibrium combination and bring about changes in p and k.[7] Given sufficient substitutability and variability of p and k, one would expect an expansion (contraction) of demand to be associated with increases (decreases) in both p and k. If substitutability or variability are low, however, the main burden of adjustment would presumably be shifted to one of the two variables and away from the other. What happens in any particular case depends on the pertinent demand and cost elasticities with respect to p and k and on the "shifts" on the demand and supply side; hence, ultimately it depends upon the host of factors that determine these parameters. For example, if sales are regarded as much more sensitive to price increases than to delivery-period increases, this in itself would favor the latter over the former as a means of reacting to actual and expected increases in demand.

It will be shown later that changes in U/S and changes in P (price indexes) for several major manufacturing industries are positively correlated. These findings support the notion that p and k tend to move in the same direction cyclically. However, in some cases the brunt of adjustment is borne to a much larger extent by price changes, in others by delivery-period changes. Either mode of adjustment results in some degree of production stabilization in the face of cyclically fluctuating demand, but the behavior over time of prices and orders can differ sharply between the two situations.

Uncertainty and Related Considerations

The future time path of sales (orders received) is, of course, uncertain; even the probabilities of the various possible paths are unknown to the firm, let alone the actual outcome. Knowledge of the present—the properties of the relevant cost and demand functions—is also quite imperfect. To reduce the area of ignorance in these matters is costly, and the costs of obtaining the information must be weighed against the returns expected from it.[8]

The hazards of uncertainty and the requirements of information are very large indeed for a manufacturer who would rely only on pricing policy to meet cyclical demand fluctuations in the manner described

[7] See Appendix H, Figure H-2, and related text.

[8] The returns depend essentially on the quality of the information, and they are themselves uncertain. See George J. Stigler, "Economics of Information," *Journal of Political Economy*, June 1961, pp. 213–25.

in the first part of this chapter. He would have to undertake much more than the difficult task of projecting sales at the existing price structure, for his forecasts need to incorporate the response of his customers and competitors to the changes in that structure due to his own active price policy. These reactions may depend on changing business conditions and may involve substantial and variable lags. Furthermore, the "sunk" costs of publicizing a new price may be a significant deterrent to frequent price adjustments in a fluctuating market.

The policy of letting backlogs accumulate and decumulate cyclically requires no such heroic efforts. The seller adopts the relatively passive attitude of accepting the fluctuations of demand instead of trying to minimize them and the corresponding output variation by sharply cyclical pricing. He need only keep more or less in step with his competitors in the price and delivery terms quoted.[9] This behavior implies that the firm acquires unfilled orders on a large scale at the same time as the rest of the industry, i.e., when the demand for their output is strong and diffused so that firms throughout the industry are working at or near capacity. In this phase, the bargaining position of the seller tends to be strong, and extensions of delivery periods will be an industrywide phenomenon and generally acceptable to the buyers. Thus, while it is true that the sensitivity of sales to the relative delivery period (D_k; see Appendix H) is not necessarily easier to estimate than the sensitivity of sales to relative price (D_p), the firm has much less need to know D_k under the policy of backlog accumulation than to know D_p under the policy of relying on price adjustments.

Concentrated ordering associated with widespread delays in delivery is often seen as current "overbuying" and an indication of probable "underbuying" sometime in the future. But when such a slack comes, it again will be recognized as an industrywide phenomenon. It is precisely in those industries where demand is generally expected to fluctuate that producers would have good reason to appreciate the advantage of increased production stability offered by backlog accumulation. In fact, various expressions of business opinion leave little doubt that manufacturers in many cyclically sensitive durable goods industries regard large order backlogs as highly desirable.[10]

[9] It seems probable that the delivery period or "lead time" is often less formally or strictly established than the price.

[10] This discussion of the costs and benefits of backlog accumulation points out the inadequacy of the view of cost adopted in Appendix H (equation 5), which can serve only as a simple first approxi-

The fact that it is durable goods that are mainly produced to order provides some support for the hypothesis that backlog adjustments are most important in industries in which demand is more unstable. Moreover, as shown in Chapter 3, industries with greater variability of cyclical and irregular movements in demand (larger averages of monthly percentage changes in cycle-trend components of new orders, $\overline{CyI_n}$) achieved a higher degree of stabilization of shipments vs. new orders (higher ratios of $\overline{CyI_n}/\overline{CyI_s}$, $\overline{Cy_n}/\overline{Cy_s}$, $\overline{Se_n}/\overline{Se_s}$, and $\bar{I}_n/\bar{I}_s$) than did the industries with smaller variability. The correlations among the ranks of the industries according to $\overline{CyI_n}$, and their ranks according to the ratios $\overline{CyI_n}/\overline{CyI_s}$, etc., are all significantly positive.

Competitive and Noncompetitive Behavior

The model of a perfectly competitive market has been interpreted in dynamic terms to mean that excess demand is corrected instantaneously by price adjustments, so that equilibrium is, in effect, continuous. Strictly speaking, this implies simultaneity of demand and supply or a zero delivery period. Price adjustments still retain their exclusive role as the equilibrating medium if the model is slightly relaxed, in which case the delivery period (k) is assumed to be positive but is treated as a constant. But it is not satisfactory to postulate this point; rather, the possibility of variable k's must be recognized. Variations over time in the average k for a given industry are compatible with a stable structure of the k-p relations, which may be enforced by competition (i.e., with stability of the contour maps in Appendix H, Figure H-1, for the different firms in the industry). If buyers are willing to wait for delivery but not willing to pay higher prices (i.e., if demand is elastic with respect to p, inelastic with respect to k), then backlogs are likely to appear or increase as demand rises. In the opposite case, price rather than backlog reactions would be dominant.

There is no necessary presumption, therefore, that the competitive

mation. The reduction of current costs due to a marginal extension of the delivery period (C_k) will presumably become larger with the transition to higher-capacity utilization levels—with increasingly less flexible inputs. But when the firm begins to accept orders for future delivery *beyond its capacity output*, it lengthens the average delivery period on its aggregate unfilled orders. Its average production costs *of the current period* (C) need not be affected thereby. But the change in the time profile of the stream of output and shipments, which is involved in this expansion of the backlog, certainly does have the effect of reducing the firm's operating costs over a longer stretch of time, as brought out in the text. A promising approach to a generalization of the cost function, which is pertinent here, has been offered in Armen Alchian, "Costs and Outputs," in Moses Abramovitz et al., *The Allocation of Economic Resources*, Stanford, 1959, pp. 23–40.

nature of the market will prevent sizable increases of delivery periods and backlogs in an industrywide boom. Such increases may and apparently do occur in industries in which the degree of competition is high, but there they are essentially market-determined, that is, they are due to short-run excess demand rather than to any policies of the individual seller (paralleling, in this respect, the cyclical increases in price levels).

Lags of price adjustments due, for example, to contractual arrangements must also be considered. And if the demand curve rose steadily, rather than by separate shifts, more persistent lags would be likely because price, though increasing, would then lag behind the rising equilibrium or clear-the-market level and would thus continue below it.[11]

In an industry in which prices are set by firms with considerable "monopoly power," the process of large-scale backlog expansion, besides feeding on a sustained pressure of demand on capacity, may also be aided by deliberate policies of "conservative" pricing. Sellers may see a conflict between higher pricing and large backlog accumulation, and may believe that the best strategy is to proceed cautiously on the former so as not to jeopardize the latter. Such price policy is not justified by the immediate situation during a boom; hence the hypothesis presumably applies only to firms that look well ahead. But in some markets the effects of a firm's current action often extend far into the future.[12] Awareness of this leads firms to longer-term policies, and these may well counsel restraint in pricing. This applies particularly to noncollusive oligopoly where aggressive price policy, which must include undercutting in the slack period, is risky, because of the uncertain reactions of the rivals, and will often be inhibited by fear of retaliation or of costly warfare. Letting the delivery periods vary may appear far less hazardous.

If competition in factor markets is also restricted, the interrelation of product and factor markets may provide an additional deterrent to a policy that would rely principally on price adjustments. Higher-wage demands by labor unions may be prompted by price increases and may be hard to resist. If wage increases are viewed as virtually irreversible, then raising the price now and lowering it in an ensuing slump would

[11] See, e.g., Kenneth J. Arrow and William M. Capron, "Dynamic Shortages and Price Rises: The Engineer-Scientist Case," *Quarterly Journal of Economics*, May 1959, pp. 299–301.

[12] In contrast effects would be limited to the present under conditions of perfect competition. See George J. Stigler, *The Theory of Price*, New York, 1952, pp. 168–69.

seem an imprudent course to follow. On the other hand, delivery periods are subject to changes that are definitely reversible—no more than the cessation of the boom is needed to reduce them again to a more nearly "normal" length.

The Effects of Changes in Buying Policies

An increase in unfilled orders may be due primarily to earlier ordering by customers rather than to the postponement of deliveries by suppliers. It may be contended that the resulting extension of the delivery periods does not increase costs to the customers since it reflects their voluntary behavior. This is a valid argument, but one must ask next to what extent the earlier ordering really represents a "voluntary" action. The ordering of materials well in advance of the time they will be needed is often prompted by the buyers' expectations of price increases or shortages. It is likely to mean that customers, in anticipation of tight supplies, are anxious to protect themselves by early, and perhaps duplicative, ordering. It is then an expression of their concern about possible delivery delays, not of their indifference to such delays. The extreme form of this behavior is a scramble for materials in times of a (current or impending) boom.

However, if efforts to cover requirements for longer periods ahead coincide in time for many buyers, the result must inevitably be an increase of orders in suppliers' books and delivery lags. Buyers will have to accept the fact that supplies have indeed tightened generally—what they feared came to pass through the working of another mechanism of collectively self-justifying expectations. If sufficiently strong, the demand pressures will have generated major price increases along with the lead-time extensions.

This period of long-range buying is likely to be followed by a phase of short-range ("hand-to-mouth") buying. Together, these phases add up to much instability over time on the demand side. But even here, where materials rather than finished goods are most important, backlog accumulation will have some stabilizing effect on output, assuming that to work off the temporary backlog of advance orders takes some time during which higher levels of production can be supported.

In contraction, a customer whose own business is doing poorly may actually have little interest in getting his orders executed promptly. He may wish to cancel some orders placed when the business outlook was better or, if this is too costly, to postpone the execution of these orders by his suppliers. To the extent the latter is done, the buyer may benefit from the deferred costs of acquiring the ordered goods and/or from the deferred or reduced costs of storing them. But this would, by the same token, impose costs on the producer-seller.

One would expect such postponements to increase the delivery periods over what they otherwise would be. The aggregative backlog-shipment ratios, U/S, which might be used as rough measures of the average delivery periods, will increase because the postponements reduce S relative to U. The effect here is one of slowing down the liquidation of a given stock of unfilled orders, of spreading the backlog U, as it were, over a longer period of time.

Some developments of this kind are likely to occur when business conditions deteriorate, and they probably help to explain why shipments decrease at a time when unfilled orders are still high. The U/S ratios kept declining through the 1948–49 and 1953–54 business contractions, but they were fairly stable for most of the durable goods industries during the 1957–58 recession and even increased a little in the recession of 1960–61 (see Charts 6-4 and 6-5). Still, judging from our data, the scope of the postponements appears rather limited.

Information on unfilled orders classified according to their time of receipt and time of scheduled shipment would help to disclose how delivery periods vary during the business cycle, reflecting buyers' policies as well as changing conditions of supply. In the absence of such data, the issues raised in this section must remain largely unresolved, at least in their quantitative aspects. However, an important qualitative inference can be drawn from the preceding discussion: The notion that longer delivery periods are burdensome to buyers and welcome to sellers does not apply in all situations. In particular, when a sudden slump occurs in the demand for their own output, buyers may actually wish to delay delivery of the orders they have placed before the disappointing development occurred, and this is certainly not a favorable development for the sellers.

The Data and Their Limitations

The Industrial Price Series

The principal body of U.S. statistics on prices in the primary (i.e., nonretail) markets is the Wholesale Price Index of the Bureau of Labor Statistics. The BLS collects prices as quoted by the sellers. Preannounced sellers' prices (list prices) are often kept unchanged for considerable periods of time, while actual transaction prices are varied by means of special discounts, sales rebates, or other concessions to the buyers.[13] List prices are therefore biased toward inflexibility and are known to understate seriously the short-term price changes. Although the BLS asks the reporting companies for actual prices received, allowing for discounts and other departures from the sellers' quotations, recent studies cast considerable doubt upon the validity of WPI data for measuring short-term fluctuations in prices. There are various reasons for, and methods of, concealing the actual transaction prices, and many sellers apparently report prices which differ little from, or tend toward, the list quotations.[14] Therefore the short-term price reactions are probably often significantly understated, although the magnitude of this bias is difficult to ascertain.

Gaps caused by the difficulty of pricing individual custom-made goods are another shortcoming of the WPI data (as already noted in Chapter 3). This has adverse effects for those industries in which the made-to-order goods not priced by the BLS are important.[15]

Finally, the need to match the price and backlog series imposes various problems and limitations on the statistical work for this chapter. In addition to individual difficulties in matching the data, there is the aggregation problem, which may be particularly troublesome in a study of price behavior. Comprehensive group price indexes had to be used, however, to produce agreement in coverage with the available aggregates of unfilled orders.[16]

Backlog Changes and Price Changes: Graphical Comparisons

Monthly changes in the price indexes for several major manufacturing industries or industry groups are shown in Chart 7-1. Along with

[13] While list prices usually represent the upper bound of the transaction prices, "extras" over the quoted price may also be imposed upon special-quality or small-quantity purchases.

[14] See Harry E. McAllister, "Statistical Factors Affecting the Stability of the Wholesale and Consumers' Price Indexes," and John Flueck, "A Study in Validity: BLS Wholesale Price Quotations," in *The Price Statistics of the Federal Government*, Report of Price Statistics Review Committee, New York, NBER, 1961, pp. 373–412 and 419–31.

[15] See Appendix C for some detail on the problems involved and on sources of price data, other than BLS, used in construction of the major-industry price indexes used in this study. It should be added that the industries here concerned (in particular transportation equipment) are also those in which military orders play a large role. It would be highly desirable to have a breakdown between military and civilian orders for these industries, but the available information is very fragmentary.

[16] The regression analysis in the next part of this chapter was completed at an early stage of this study and included only the major-industry series on unfilled orders which were then available (these are the OBE data prior to the 1963 revision). Some replications using recent Census data will also be presented below.

Chart 7-1

Monthly Changes in Deflated Unfilled Orders (Backlogs) and in Price Indexes, Nine Major Manufacturing Industries, 1948–58

(change in backlogs: millions of dollars in average 1947–49 prices; change in prices: index, 1947–49 = 100)

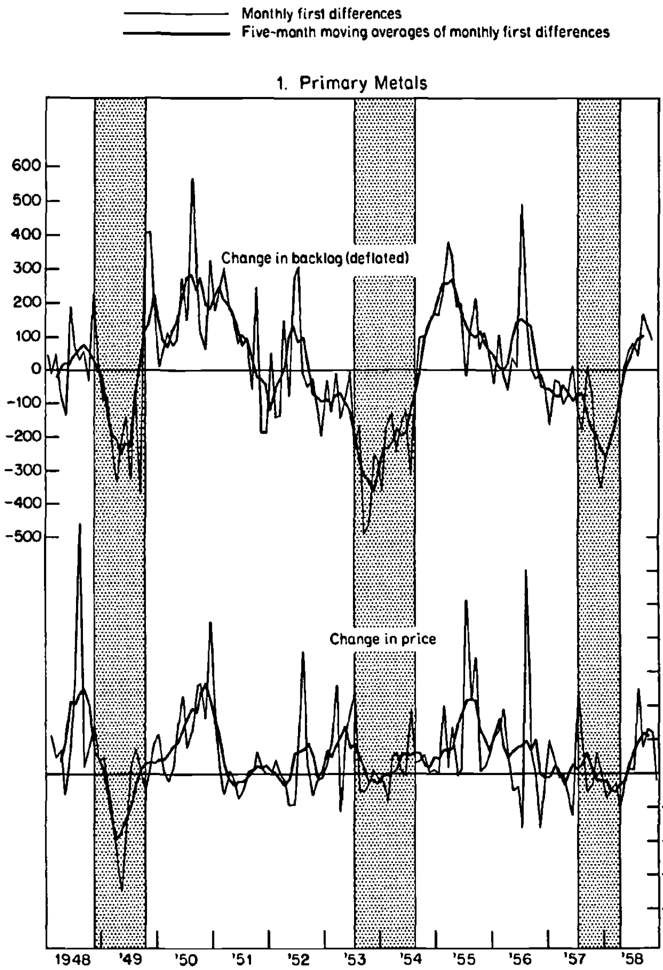
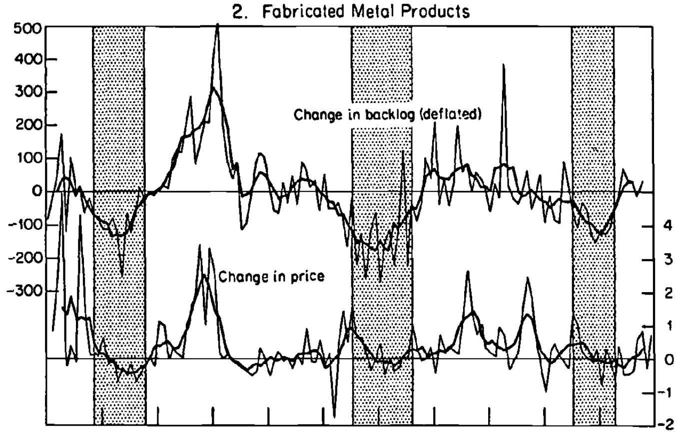


Chart 7-1 (continued)



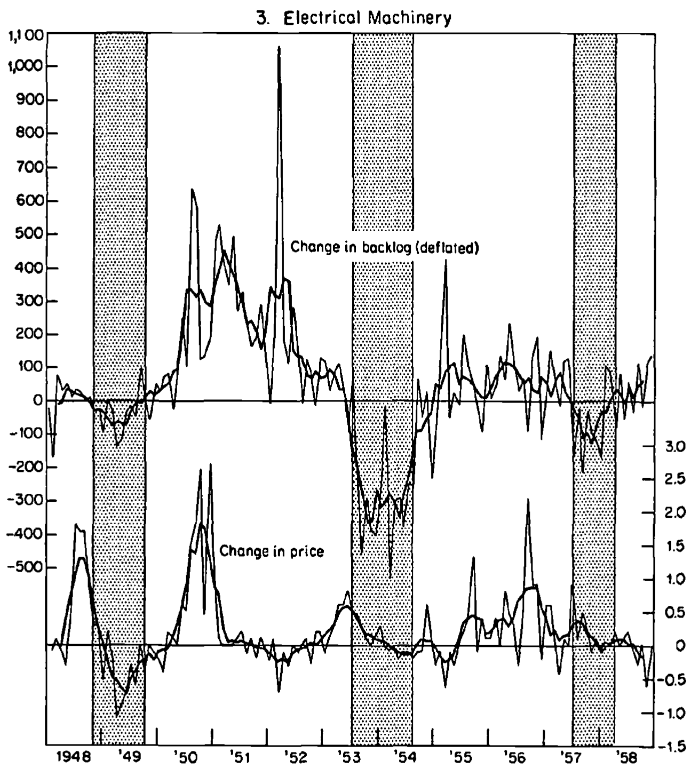


Chart 7-1 (continued)

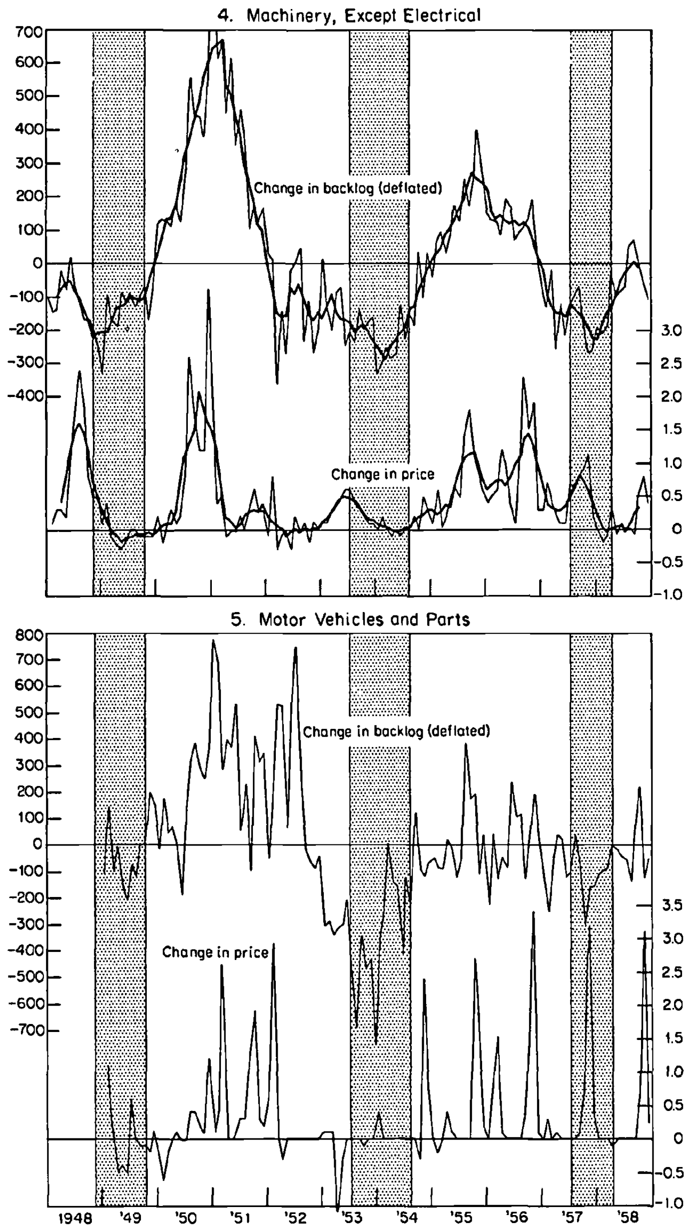


Chart 7-1 (continued)

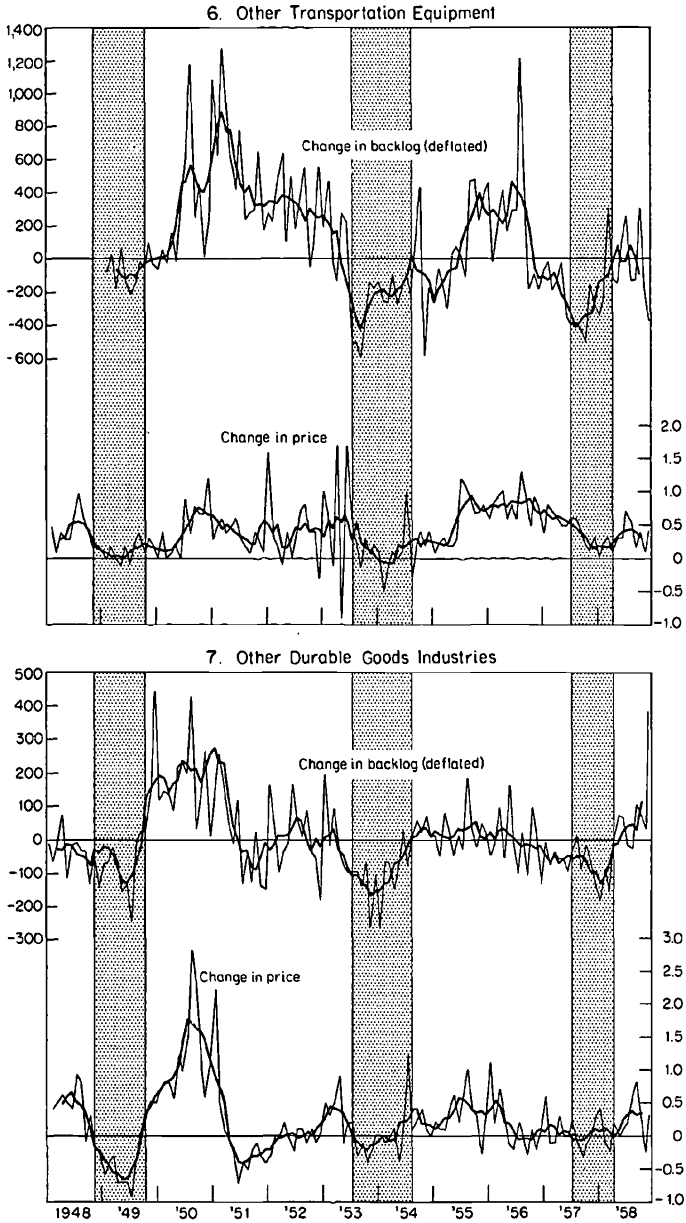
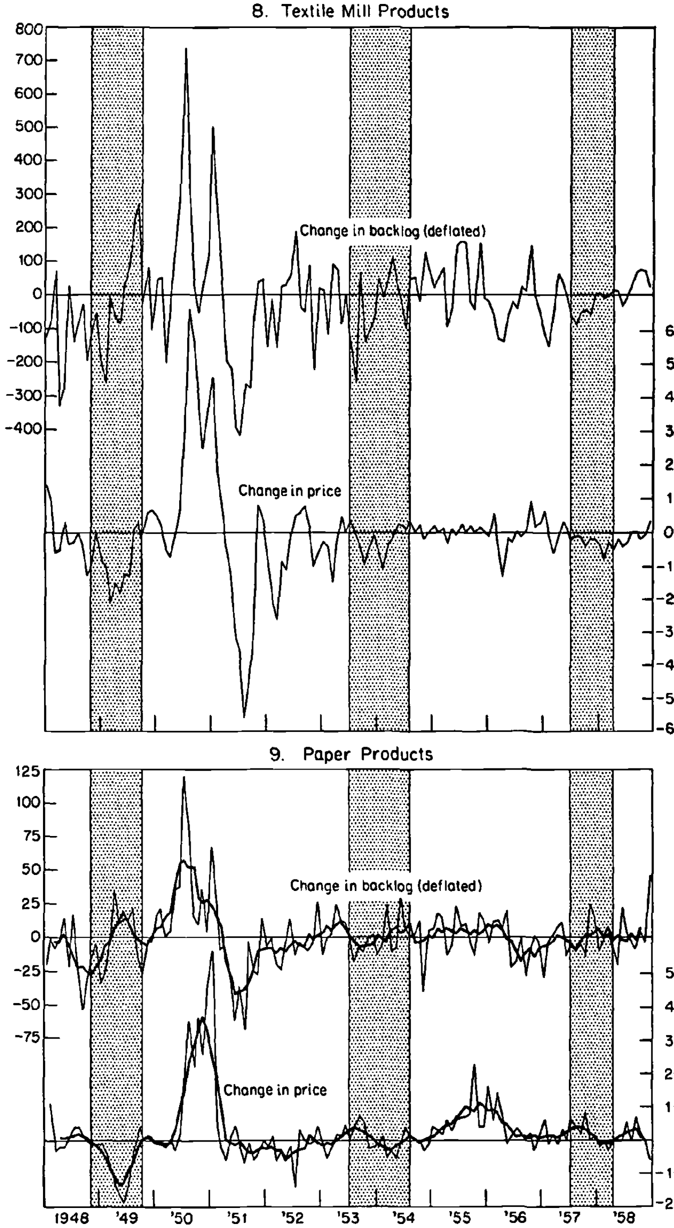


Chart 7-1 (concluded)



Note: Shaded areas represent business cycle contractions; unshaded areas, expansions.

Source: U.S. Department of Commerce, Office of Business Economics, and U.S. Department of Labor, Bureau of Labor Statistics.

these data, the chart shows the corresponding series of monthly first differences in deflated unfilled orders. The regression analysis in the next part of this chapter is based on these series of short-period price and backlog changes.

The deflation procedure, analogous to that applied to the series of new orders and shipments (see Chapter 3 and Appendix C), had little effect on the short-term movements of the series concerned because the month-to-month changes in measured prices are very small relative to those in backlogs. It must be recognized that deflation procedures are usually crude and risky. Their application to stock magnitudes such as unfilled orders or inventories is particularly difficult, since the prices used for items included in such aggregates were obtained at various points of time.[17]

It is evident from the graphs that the series of monthly changes in prices and unfilled orders of the major manufacturing industries are highly erratic; to be sure, this is often the case for economic indicators cast in short-unit periods and in a first-difference form. In the backlog series, however, the cyclical movements are pronounced, while in the price series they are much weaker and often obscured by short irregular variations. Among the backlog changes, negative as well as positive values are common, whereas the price changes are overwhelmingly positive, reflecting the dominance of upward trends in the postwar records of industrial price indexes proper.

The first-difference series of Chart 7-1 probably contain relatively large errors of observation. This is so because short-term changes in price and backlog (ΔP and ΔU) are typically small in comparison with the corresponding "totals," i.e., the prices and backlogs proper (P and U); thus, even errors that are small relative to P and U are likely to be large relative to ΔP and ΔU.[18] If only because of the influence of large random errors, then, one would not expect the monthly ΔP and ΔU series to show high correlations. There is indication in the graphs,

[17] This problem cannot be solved in any satisfactory manner with the limited information on hand. Our backlog-change estimates in constant dollars were derived simply by taking monthly differences between deflated values of new orders and deflated shipments.

[18] For example, assume (rather optimistically) that the accuracy of a price index is within ± 0.1 of one index point. Let the lowest observed standing of the index be 80 and the highest, 140 points. Then the error in the price proper varies between 0.07 and 0.125 per cent. But the average monthly first difference may well be slightly less or slightly more than one index point. Even if it were as large as two points, errors of observation would equal up to 10 per cent of $\Delta P(2.0 \pm 0.2)$. Actually, it is more likely that the errors are more disturbing still, perhaps accounting for 20–25 per cent of the total variance in ΔP.

however, that significant positive correlations do exist between the longer and more systematic—predominantly cyclical—movements in these series for a number of industries. (Note the moving averages superimposed on the monthly series in Chart 7-1).

The ΔU series typically expand in the early stages of business expansions, and contract in the later stages. This is also true of the ΔP series, though with less regularity. The ΔP series often do not descend below zero even in recession. The downward inflexibility of industrial prices was particularly marked in the business contraction of 1953–54, somewhat less so in that of 1957–58. In the 1947–48 recession, on the other hand, the ΔP series did fall below zero in most cases.

Marked interindustry differences in the behavior of the paired series shown in Chart 7-1 must also be noted. In some cases, the data do not appear sufficiently meaningful to warrant their use in further tests.[19]

Some Tests, Estimates, and Interpretations

Price Change vs. Backlog Change, by Broad Industry Groups

The first hypothesis to be tested is that the greater the importance of production to order and the longer the delivery lags, the greater will be the role of backlog reactions relative to that of price reactions. This is borne out strongly by the available evidence for major manufacturing industries.

In Table 7-1, column 7 lists the regression coefficients b computed by least squares from the equation

$$(\Delta P)_t = a + b(\Delta U)_{t-j} + u_t, \tag{1}$$

where ΔP is the change in the price index for the output of the corresponding industry and ΔU is the change in the backlog of the industry's unfilled orders (in millions of dollars, deflated). Quarterly data

[19] Consider the motor vehicle industry, where the price index proper, based on rigid quotations, assumes the form of a step curve. In terms of ΔP, this means zero values and sharp up-and-down movements to and from the zero level, as shown in the chart (the seasonal element is evident in the timing of these shifts in recent years). It may well be questioned to what extent this picture is representative of the behavior of actual transaction prices. Moreover, there are also problems with the unfilled orders data for this industry. It would clearly be futile to relate reported ΔP to ΔU in this case.

In no other instance does ΔP behave in a similarly extreme fashion. However, the series for the leather and printing and publishing industries were also excluded because of their particularly erratic behavior and questionable quality.

are used, and ΔU is taken either with simultaneous timing or with a lead of one quarter relative to ΔP, whichever gives a higher correlation. The regression coefficients are all significantly positive, and their ranks (column 8) show a very high inverse correlation with the ranks of the average U/S ratios (−.976). These rankings appear to make good sense in terms of the relevant differential characteristics of the industries included.[20]

Table 7-1, column 9, shows the ratios of the standard deviations of ΔP and ΔU. These ratios represent another measure of the relative role of price and backlog adjustments in that they compare the average size of variations in ΔP and ΔU for different industries. Again, correlation between the ranks of the average U/S values and of the standard deviations is high and inverse (−.881).

There is some danger of spurious correlation in these tests. Larger absolute U/S ratios may be associated with larger absolute values of U, and thus also with ΔU that are larger absolutely and relative to ΔP. However, while U and S depend on industry size, U/S and P do not. Column 11 lists the regression coefficients b' computed by least squares from the equation

$$(\Delta P)_t = a' + b'\Delta(U/S)_{t-j} + u'_t. \tag{2}$$

The correlation between the ranks of the average U/S values and the ranks of the b' coefficients is also negative and high.

Column 13 gives the ratios of the standard deviations of ΔP and $\Delta(U/S)$. The ranks of these ratios show a perfect negative correlation with the ranks of the average U/S values.

Further tests based on the average leads of new orders in relation to shipments (column 2) are free from all possibility of spurious correlation. The correlations between the ranks of these leads and the ranks of the regression coefficients and standard deviation ratios are all negative and substantial (last line of table).

The ranks of the average U/S ratios and of the regression and dispersion measures used in Table 7-1 would not be very sensitive to data

[20] For example, the paper industry not only has small backlogs but its finished inventory is even smaller (Table 2-1). Hence current price and output adjustments are, as expected, very important here. The weight of manufacture to stock is probably larger in textiles, other durables, and electrical machinery than in the other industries, but this could not be inferred from our gross measures, perhaps because the role of backlog adjustments is much greater than that of product stock adjustments in all these industries.

Table

Average Backlog-Shipment Ratios, Average Leads of New Orders, Measures, Eight Major

Industry	Average Monthly U/S Ratio[a] (1)	Average Lead of New Orders at Turns in Shipments: Months[b] (2)	Rank[c] (3)	Standard Deviation[d] of: Price Change (index points) (4)	Backlog Change (mill. dol.) (5)	Change in U/S Ratio (6)
Paper and allied products	0.65	1.7(6)	2	2.46	51.35	.069
Textile-mill products	1.63	3.3(6)	3	3.52	362.39	.358
Other durable goods[i]	1.92	0.9(8)	1	1.46	324.55	.145
Primary metals	2.99	3.5(8)	4.5	3.29	498.66	.364
Fabricated metal products	3.55	3.9(7)	6	2.10	308.11	.356
Nonelectrical machinery	4.20	4.0(6)	7	1.64	677.53	.428
Electrical machinery	6.04	3.5(6)	4.5	1.53	529.67	.550
Nonautomotive transportation equipment[j]	16.85	11.5(4)	8	0.87	951.59	.982
Rank correlations (Spearman coefficients):						
With average U/S ratios (col. 1)						
With average lead of orders (col. 3)[k]						

Source: Unfilled and new orders and shipments: Based on data from the U.S. Department of Commerce, Office of Business Economics; Prices (i.e., components of the WPI index, 1947–49 average = 100): U.S. Department of Labor, Bureau of Labor Statistics. The OBE data are of the pre-1963 vintage.

[a] Listed from the lowest to the highest. Covers 1948–58 (132 observations), except for nonautomotive transportation equipment for which data cover 1949–58 (120 observations).

[b] Covers 1948–58. The figure in parentheses gives the number of observations for each industry. See also text and footnote 21.

[c] Ranked from the shortest to the longest.

[d] Based on quarterly data.

[e] Coefficient b from the regression $\Delta P_t = a + b(\Delta U)_{t-j} + u_t$. Quarterly series (converted from monthly) used throughout. Leads of one quarter ($j = 3$) used for paper, nonautomotive transportation equipment, and fabricated metal products; simultaneous relationships ($j = 0$) used for the remaining industries. These timing relations maximize simple correlations between ΔP and ΔU in quarterly terms.

7-1

Regressions of Price Change on Backlog Change, and Related Manufacturing Industries, 1948–58

Av. Change[d] in ΔP Per Mill. Dollars of Change in ΔU		Ratio of Standard Deviations[d] of ΔP and ΔU		Av. Change[d] in ΔP Per Unit Change in $\Delta(U/S)$		Ratio of Standard Deviations[d] of ΔP and $\Delta(U/S)$	
Index Points[e] (7)	Rank[c] (8)	Per Cent[f] (9)	Rank[c] (10)	Index Points[g] (11)	Rank[c] (12)	Ratio[h] (13)	Rank[c] (14)
.03190	8	4.790	8	23.85	8	36.72	8
.00664	7	.972	7	6.39	7	11.57	7
.00308	6	.450	4	4.30	6	10.25	6
.00277	4	.661	5	1.12	3	8.39	5
.00305	5	.682	6	1.40	4	5.79	4
.00110	3	.243	2	1.67	5	3.57	3
.00049	2	.287	3	0.41	2	2.56	2
.00037	1	.092	1	0.25	1	0.90	1
	−.976		−.881		−.905		−1.000
	−.786		−.643		−.697		−0.816

[f] Equals the ratio of $\sigma(\Delta P)$ in column 4 to $\sigma(\Delta U)$ in column 5 multiplied by 100. Also equals the ratio of the regression coefficient b in column 7 to the corresponding correlation coefficient r in column 5 of Table 7-2, multiplied by 100.

[g] Coefficient b' from the regression $\Delta P_t = a' + b'\Delta(U/S)_{t-j} + u'_t$. Leads of one quarter ($j = 3$) used for paper and fabricated metal products; simultaneous relationships ($j = 0$) assumed for the remaining industries. These timing relations maximize simple correlations between ΔP and $\Delta(U/S)$ in quarterly terms.

[h] Equals the ratio of ΔP to $\Delta(U/S)$ for the periods covered by the appropriate data. (These ratios differ slightly from those obtained by dividing column 4 by column 6 because of differences in time coverage between the figures in these columns.) Also equals the ratio of the regression coefficients b' in column 11 to the corresponding correlation coefficients r in column 1 of Table 7-5, multiplied by 100.

[i] Includes professional and scientific instruments; lumber; furniture; stone, clay, and glass; and miscellaneous industries.

[j] Backlog data are not available before 1949.

[k] The coefficients in this line are all adjusted for the tie in the ranks of the average order leads of primary metals and electrical machinery (column 3).

sions and errors of observation, but the timing measures and their tive size could be strongly affected. The tabulated results are based on the analysis of the old OBE data. In an effort to see whether they are validated by the new Census series, average leads of N relative to S, estimated from the revised (1963) data, were substituted for the averages shown in column 2 of the table. The ranks of these new timing measures (for the same period, 1948–58) are found to be in each case negatively correlated with the ranks of the regression coefficients and standard deviation ratios, though these correlations are lower than their counterparts in Table 7-1 (last line).[21]

Further Implications

The analysis in the first part of this chapter implies that, given the amplitude of fluctuation in demand, the more the average delivery period fluctuates the less does the average price, and vice versa. This proposition is difficult to test with the available data, but Table 7-1 provides some evidence that seems at least consistent with it. Thus, in addition to the negative correlations listed in the last two lines of the table, there are also negative rank correlations between the standard deviations of ΔP and ΔU and between those of ΔP and $\Delta(U/S)$. The Spearman coefficients here are −.452 and −.405, respectively.

These comparisons, however, make no explicit allowance for inter-industry differences in the amplitudes of demand fluctuations. As argued before, greater variability of demand may signify greater uncertainty, which is likely to be associated with more backlog variation and less price variation. In fact, the standard deviations of both the deflated new orders and the first differences in new orders are found to be negatively correlated with $\sigma(\Delta P)$ and positively correlated with $\sigma(\Delta U)$ and $\sigma\Delta(U/S)$.[22] The rank correlations (Spearman coefficients) for the eight industries included in Table 7-1 are shown below.

	$\sigma(\Delta P)$	$\sigma(\Delta U)$	$\sigma\Delta(U/S)$
$\sigma(N)$	−.667	+.857	+.667
$\sigma(\Delta N)$	−.381	+.500	+.381

[21] The new average lead figures, which are based on the observations listed in Tables 4-6 and 4-8, are, in months: paper, 1.5; textiles, 3.5; other durable goods, 1.0; primary metals, 4.1; fabricated metal products, 5.1; nonelectrical machinery, 3.7; electrical machinery, 1.8; and nonautomotive transportation equipment, 11.5. The correlation between the ranks listed in Table 7-1, column 3, and the ranks based on the above figures is .874. When the new data are used, the following rank correlations corresponding to those shown in the last line of Table 7-1 are obtained: with b (column 8), −.571; with $\sigma(\Delta P)/\sigma(\Delta U)$ (column 10), −.357; with b' (column 12), −.643; and with $\sigma(\Delta P)/\sigma[\Delta(U/S)]$ (column 14), −.595.

[22] Deflated new orders can be regarded as an index of demand—of the indifference curves in Ap-

Among the implications of the analysis is that, within a given industry, delivery periods and prices should be negatively correlated at any one time. The cross-sectional tests needed to confirm this cannot be made because data for firms grouped by homogeneity of product are lacking.[23]

A Regression Analysis of Lagged Price Adjustments

It is plausible to assume that prices react mainly to the more systematic and persistent variations in the demand-delivery conditions. Pursuing this notion, we have applied to the data two types of *distributed-lag* relation. The simpler of these is a regression of ΔP for the current quarter on ΔU's for the current and previous quarters. The resulting multiple correlation coefficients are substantially higher in some cases than the maximum simple correlations of quarterly data (Table 7-2, columns 5 and 6).[24]

For the second distributed-lag approach, equations of the Koyck form

$$(\Delta P)_t = a_1(\Delta U)_{t-j} + b_1(\Delta P)_{t-1} + c_1 + u_t \tag{3}$$

were fitted to the monthly data. The timing $(t-j)$ here is the lead that maximizes the simple correlation between monthly ΔP and $\Delta U (j \geqslant 0)$. The results are presented in Table 7-2, columns 2–4. The regression coefficients a_1 and b_1 all have the anticipated positive sign. All but one of them are highly significant, in the sense of being different from zero at least at the .01 level.[25]

Although significant, the a_1 coefficients are very small throughout, being measured in thousandths of a price-index point per $1 million

pendix H, Figure H-2. Our theoretical argument suggests that variations in this index are met partly by price and delivery-period adjustments. Thus, the indicated association is between P and U/S on the one hand and N on the other, or between the changes in each of these variables. Actually we find that ΔP and $\Delta(U/S)$, as well as ΔU, are positively associated with both ΔN and N.

[23] In the absence of such information, it may be noted that descriptions of trade practices offer examples of price discounts granted the advance buyer (see, e.g., Temporary National Economic Committee, *Geographical Differentials in Prices of Building Materials*, 76th Cong., 2nd sess., Washington, D.C., 1940, pp. 66 and 288).

[24] In turn, the simple correlations with quarterly series are for the most part appreciably higher than those with monthly series (see Table 7-2, columns 1 and 5). This may be due to a reduction in the influence of measurement errors and to the smoothing obtained by conversion to quarterly data.

[25] The exception is the b_1 for nonautomotive transportation equipment. Presumably the distributed-lag scheme does not apply in this case. The R coefficient also is very low for this industry, considerably less than even the simple r obtained for the quarterly series (Table 7-2, columns 2 and 5). In two other industries, fabricated metal products and paper, similar, though weaker, inferences are indicated. For the remaining four industries, the Koyck-type distributed-lag approach does result in correlations that exceed significantly the R's computed by relating ΔP_t to ΔU_t and ΔU_{t-1} in quarterly terms (Table 7-2, columns 2 and 6).

Table 7-2

Relations Between Price Changes and Backlog Changes, with Simple and Distributed Lags, Seven Major Industries, 1948–58

Industry [a]	*r*: Simple Lag [b] (monthly) (1)	Distributed Lags [c] (monthly) *R* (2)	Regression Coefficient of ΔU_{t-j} (3)	Regression Coefficient of ΔP_{t-1} (4)	*r*: Simple Lag [d] (quarterly) (5)	*R*: Lags of 1 and 2 Quarters [e] (6)
Paper and allied products	.549(5)	.747(5)	.0119 (.0029)	.5723 (.0695)	.666(3)	.824
Textile-mill products	.656(1)	.872(0)	.0032 (.0004)	.7075 (.0427)	.683(0)	.786
Other durable goods [f]	.558(0)	.742(0)	.0012 (.0002)	.5577 (.0595)	.685(0)	.696
Fabricated metal products	.311(0)	.458(0)	.0018 (.0006)	.3475 (.0795)	.447(3)	.478
Nonelectrical machinery	n.a.	.681(0)	.0005 (.0002)	.5994 (.0628)	.453(0)	.455
Primary metals	.432(1)	.480(1)	.0028 (.0006)	.2152 (.0782)	.419(0)	.449
Nonautomotive transportation equipment [g]	n.a.	.245(0)	.0003 (.0001)	.0446 [h] (.0898)	.404(3)	.437

n.a. = not available.

Source: Same as Table 7-1.

[a] Ranked by the multiple correlation coefficients in column 6, from highest to lowest. Electrical machinery, one of the industries covered in Table 7-1, is omitted here. It shows correlations between ΔP and ΔU that are much lower than those for the other industries (e.g., a simple correlation in quarterly terms of .171).

[b] The lags of ΔP relative to ΔU (in months) are given in parentheses. These timing relations maximize simple correlations between ΔP and ΔU in monthly terms.

[c] Based on regressions of ΔP_t on ΔU_{t-j} and ΔP_{t-1} (see text). Parenthetical figures in column 2 indicate the lags of ΔP relative to ΔU (the j's): those in column 3 indicate calculated standard errors.

[d] The lags of ΔP relative to ΔU, converted from quarters to months, are given in parentheses (0 = simultaneous timing; 3 = one-quarter lag). These correlation coefficients correspond to the regression coefficients in Table 7-1, column 7.

[e] Based on regressions of ΔP_t on ΔU_t and ΔU_{t-3}. The number of observations (number of quarterly intervals covered by all three series) is 43 for each industry, except textiles (42) and nonautomotive transportation equipment (38). The same number of observations applies to the corresponding simple correlations in column 5.

[f] Includes professional and scientific instruments; lumber; furniture; stone, clay, and glass; and miscellaneous industries.

[g] Measures refer to 1949–58 because backlog data are not available before 1949.

[h] Not significant.

change in the constant-dollar value of ΔU_{t-j}. The b_1 coefficients are of the order of tenths of an index point per index point. If accepted at their face value,[26] these results suggest that the price reactions measured here are small and rapid; their speed is inversely related to the value of b_1. Indeed, the sums of the implicit lag coefficients, $\Sigma = a_1/(1 - b_1)$, which may be taken to reflect the cumulative effect upon ΔP_t of all past changes in ΔU, are not more than 1.3 to 2.3 times the value of the corresponding a_1 coefficients in Table 7-2, which measure the impact of the single initial change in ΔU_{t-j} (except for textiles, where the ratio is about 5). This indicates that the processes involved are relatively short for most of the industries. The "half-life" estimates of the number of months (n) needed to account for 50 per cent of Σ range from 0.5 for primary metals to 2.0 for textiles; the figures for 70 per cent absorption range from 0.8 to 3.5 months; those for 90 per cent absorption, from 1.5 to 6.7 months.[27]

Our measures suggest that the price reactions are particularly weak in those durable goods industries in which backlogs are typically large and widely fluctuating (metalworking, machinery, and nonautomotive transportation equipment). For textiles, paper, and the other durables group, where average levels of and changes in backlogs are much smaller, the prevalence of stronger price adjustments is indicated.

A Comovement Analysis

Inspection of the graphs in Chart 7-1 suggests that it might be of interest to separate the *direction* from the *magnitude* of change in studying the relations between ΔU and ΔP. The correlation analysis takes both elements into account, but it may deny the existence of a significant relation between two series which move consistently in the same direction, because of large changes in the relative size of such "comovements." The analysis may also testify to a strong positive relation between series that often move in opposite directions if such countermovements are sufficiently small relative to the fewer but larger comovements. Nonparametric tests of the degree of agreement

[26] The pitfalls of least-squares estimation of models in which lagged values of the dependent variable occur as independent variables have been noted before in Chapter 5.

[27] These measures are computed from the formulas $q = 1 - b_1^n$ and $n = \log(1 - q)/\log b_1$, where q is set to equal 0.5, 0.7, and 0.9, alternately. They are analogous to the estimates presented in Chapter 5 for the *N-S* relations (see Tables 5-4 and 5-5 and the accompanying text).

in the direction of movements are available.[28] The results of applying such tests to quarterly backlog and price changes are summarized in Table 7-3.

For example, for textiles, ΔU increased twenty-one times in a total of forty-three comparisons, and ΔP increased eighteen times in the same number of comparisons. If the two variables were independent, the expected number of instances in which both ΔU and ΔP were rising would be $(21/43)(18/43)43 = 8.8$, and the expected number of instances in which both were falling would be $(22/43)(25/43)43 = 12.8$. Hence the expected total of all comovements would be $8.8 + 12.8 = 21.6$. But actually the number of all observed comovements of the two textile series was substantially larger, namely, 28. A comparison of the observed and the expected comovements shows that, for each of the seven industries covered, the number of observed comovements exceeded the figure that would be expected on the assumption of independence.

A further step can be taken by computation of the statistic K (Table 7-3, last line, and defined in note d). This is simply an application of the chi-square procedure to the 2 by 2 table describing the joint distribution of n pairs of signs of ΔU and ΔP. For one degree of freedom, the values of chi are normally distributed. Under the null hypothesis of independence between the sign series, then, the distribution of K would be approximately normal with zero mean and unit variance. The appropriate probabilities of the observed K values, taken from the table of areas under one tail of the normal curve, are given in parentheses under the values of K. These probabilities turn out to be quite low, indicating significance on the levels of 1 to 4 per cent in all industries except nonelectrical machinery and primary metals.[29]

[28] See Geoffrey H. Moore and W. Allen Wallis, "Time Series Significance Tests Based on Signs of Differences," *Journal of the American Statistical Association*, June 1943, pp. 153–64; and Leo A. Goodman and Yehuda Grunfeld, "Some Nonparametric Tests for Comovements Between Time Series," *ibid.*, March 1961, pp. 11–26 (see the latter paper for other references). A test of the type described in the next paragraph of the text has been applied by Grunfeld in "The Determinants of Corporate Investment," in Arnold C. Harberger, ed., *The Demand for Durable Goods*, Chicago, 1960, pp. 221–32.

[29] It should be noted that K as given in Table 7-3 includes no correction for continuity of the normal curve or for the fact that the signs of first differences in a purely random series are negatively autocorrelated. Had such corrections been made, K would have been lowered and the associated probability would have been increased. But it was found that the adjustment for autocorrelation (as proposed by Goodman and Grunfeld, "Some Nonparametric Tests") reduced the K figures only slightly. Thus, the K for nonautomotive transportation equipment, a suitably low-ranking statistic, is reduced by such an adjustment from 1.802 to 1.796.

Table 7-3
Analysis of Comovements in Quarterly Changes of Backlogs and Prices, Seven Major Industries, 1948–58

	Number of Observations (quarter-to-quarter comparisons)						
Direction of Movement[a] in ΔU and ΔP	Textile-Mill Products (1)	Paper and Allied Products (2)	Other Durable Goods (3)	Fab. Metal Products (4)	Nonelect. Mach. (5)	Primary Metals (6)	Nonautomotive Transport. Equip. (7)
Both series rise (RR)	12	15	14	13	16	9	13
Both series fall (FF)	16	14	14	17	10	14	11
Rise in ΔU, fall in ΔP (RF)	9	8	7	4	10	9	7
Fall in ΔU, rise in ΔP (FR)	6	6	7	8	7	11	6
Total number of comparisons (n)[b]	43	43	42	42	43	43	37
Observed comovements ($RR + FF$)	28	29	28	30	26	23	24
Expected comovements[c]	21.6	21.5	21.0	21.0	21.8	21.7	18.5
K (probability of K in parentheses)[d]	1.98 (0.024)	2.30 (0.011)	2.16 (0.015)	2.83 (0.002)	1.31 (0.095)	0.39 (0.348)	1.80 (0.036)

[a] For textiles, other durables, nonelectrical machinery, and primary metals, ΔP_t is compared with ΔU_t. For the other industries, the comparisons are between ΔP_t and ΔU_{t-1}. This choice of the timing relations follows the results of Table 7-2, column 5.

[b] $n = RR + FF + RF + FR$.

[c] See text.

[d] $K = (RR \times FF - RF \times FR)\sqrt{n}/\sqrt{[(RR + RF)(RR + FR)(FF + RF)(FF + FR)]}$. See text for further explanation of K and the associated probabilities.

The industry with the lowest correlations in Table 7-2, nonautomotive transportation equipment, scores fairly well on the evidence of the comovement test of Table 7-3. This industry shows a particularly strong contrast between the huge backlog changes and the minuscule price changes (Chart 7-1 and Table 7-1). There is no reason to doubt that this reflects a real phenomenon: in this case, the great relative importance of backlog and delivery-period adjustments. The comovement test confirms the existence of a positive association between ΔP

and ΔU. The correlation measures may have understated this association because the values of ΔP are frequently understated, though correct in sign (note the virtual absence of negative values in this series in Chart 7-1).

Models with Finished Stocks and Unfilled Orders

Like the divergence between new orders and shipments in production to order, the divergence between shipments and output in production to stock gives expression to the changing demand and supply conditions that influence price. A sufficiently systematic or persistent increase (decrease) in the orders backlog may indicate positive (negative) excess demand; by an analogous argument, corresponding indications might be obtained from a similar decrease (increase) in finished-goods inventories for nonperishable commodities made to stock.[30]

The main difficulty of price adjustment models that incorporate changes in finished stock is that the change may be desired by the seller. If slackening sales leave a producer with undesired inventory of unsold output on his hands, he may offer or accept a lower price. But if the stock increase does not represent excess supply, but rather the firm's planned investment in its own product, there is clearly no reason for a price reduction. The problem, then, is how to distinguish the planned from the unplanned component in the stock variable.[31]

The first approach to this problem on the theoretical level was to assume that the change in price is a negative function of the difference between the actual and some "normal" value of the product inventory.[32] In practice, the difficulty of ascertaining what constitutes a

[30] As $U = N - S$, systematic movements in this variable may be regarded as indicative of systematic changes in quantities demanded relative to quantities supplied. In this view, the distributed-lag regressions of Table 7-2 show that increases and decreases in "excess demand" tend to be associated with increases and decreases, respectively, in ΔP (both variables being taken with regard to sign). This, of course, assumes production to order where S and N differ substantially and S and Z are closely correlated (indeed, for not too short a period, approximately equal). In production to stock, where $S \simeq N$ represents quantities demanded, i.e., ordered and shipped from stock, it is the change in finished stock, ΔQ and $Z - S$, which could perhaps be used similarly as an indication of movements in excess demand.

[31] In dealing with production to order, it is also possible that backlog changes may be wanted; the producer's desire to attract more orders for future delivery may have a braking effect upon the tendency of price to increase in times of rising demand. But the time-path of the backlog depends primarily upon the course of sales (new orders), over which the producer ordinarily has only a limited degree of indirect influence. On the other hand, attempts to alter the stock level, which involve increases or decreases in the output rate, are within the power of the firm. There is both more of the volitional element here and more difficulty in allowing for it than in the case of backlog change.

[32] An assumption to this effect by Francis Dresch was given early consideration by Paul A. Samuelson in "The Stability of Equilibrium: Comparative Statics and Dynamics," *Econometrica*, April 1941, pp. 107 ff.

normal level of stock in any particular case is formidable. In a more general theoretical model, the current price of a durable good is viewed as determined not by the current flow functions of demand and supply but by demand for and supply of the existing aggregate stock of the good.[33]

For a single-product firm producing to stock but accepting advance orders in periods of exceptionally brisk demand, the change in price may depend on backlog change (Δu) during the boom and on stock change (Δq) the rest of the time. Thus, the price adjustment model should incorporate both Δu and Δq as determinants of Δp and should involve some "switching rule" for the transition from one of the estimators to the other. In practice, data refer to multifirm, multiproduct industries, where there may be some alternation between the two types of production, but probably some products would typically be made to stock and others to order most of the time. For such an industry, one can only expect that the aggregative data would show a positive association between ΔP and ΔU and a negative association between ΔP and ΔQ, both holding continuously over time. In order to secure material on the relative merits of different types of price adjustment equations, a number of computations were made for data on the paper industry.[34]

The results of these experiments are listed in Table 7-4. The first part of the table shows the simple correlations computed from monthly data, with ΔP assumed to lag behind either ΔU or ΔQ by intervals varying from 0 to 6 months. The coefficients for the ΔP vs. ΔQ relation are all negative, as expected, but they are much lower absolutely than the (positive) coefficients for the relation between ΔP and ΔU.

The correlations between the quarterly series (middle part) are much

[33] R. W. Clower, "An Investigation into the Dynamics of Investment," *American Economic Review*, March 1954, pp. 64–81. This is price determination for a very short period. Over time, current flows of production and consumption will add to and subtract from the stock, and the stationary as distinguished from the momentary equilibrium requires that excess demand be zero for the flow as well as for the stock functions. The stock-flow model provides a useful reminder that the influence of the current flows upon the price of a durable good is limited by the existence of an accumulated stock of that good. However, if the flows are measured over longer periods than those assumed in Clower's analysis, their short-run influence on price will not be negligible for many durable goods; for many durable and especially nonstaple goods, accumulated stocks would not be overwhelmingly large relative to outputs. Also, it may be argued that the stock influence will be less for durables made to order than for other durable goods because the former are held principally by buyer-users, whereas the latter are held also by producer-sellers.

[34] The paper industry was selected because data on U and Q were available; because both production to order and production to stock are well represented, although there is evidence that the overall share of the former is larger; and because the simple regressions for paper showed relatively long lags of price change, a pattern promising more scope for experimentation.

Table 7-4

Prices vs. Unfilled Orders and Finished Inventory, Regressions with Various Lags, Paper and Allied Products Industry, Monthly and Quarterly Changes, 1948–58

	Assumed Lead of Independent Variable Relative to ΔP (mos.)						
	0	1	2	3	4	5	6
	COEFFICIENTS OF SIMPLE CORRELATION						
1. ΔU	.366	.350	.401	.416	.467	.549 [a]	.450
2. ΔQ	–.070	–.194	–.226	–.195	–.232	–.235 [a]	–.105

	Simple Regressions,[b] Quarterly; One-Quarter Lags of ΔP				
	Regression Coefficients		Standard Error of Estimate	r	r^2
	Intercept	Slope			
3. ΔU	–.145	.031	1.59	.717	.514
4. ΔQ	.582	–.126	4.50	–.424	.180

	Multiple Regressions, Monthly; Distributed Lags [c]					
		Regression Coefficients of				
	Intercept	$\Delta U(-5)$	$\Delta Q(-1)$	$\Delta P(-1)$	R	R^2
5. $\Delta U(-5), \Delta P(-1)$	.095	.0119 (.0029)		.5723 (.0695)	.747	.558
6. $\Delta Q(-1), \Delta P(-1)$	.135		–.0362 (.0159)	.6936 (.0644)	.719	.517

[a] Highest correlation coefficients, denoting the lead that maximizes correspondence between ΔP and ΔU or between ΔP and ΔQ.

[b] Change in trend-adjusted price series was used as dependent variable in these regressions, which led to some slight improvements in correlation as compared with the use of the trend-unadjusted data.

[c] ΔU used with a five-month lead, ΔQ with a one-month lead, over ΔP. These are the leads that maximize the multiple correlations with ΔP, given $\Delta P(-1)$ as the second independent variable. Figures in parentheses are calculated standard errors of the regression coefficients.

higher in each case than the best correlations based on monthly data. Here, too, ΔP is considerably better correlated with ΔU than with ΔQ.

The bottom part of the table shows the results obtained by application to these relations of the distributed-lag approach of the Koyck type. The relations with ΔU have a small advantage over those with ΔQ in the multiple correlations, and they yield more significant regression coefficients.

I have also experimented with a multiple regression model in which both ΔU and ΔQ are included as determinants of price change. Taking ΔU with a five-month and ΔQ with a two-month lead over ΔP, a correlation of .557 is obtained, which is only a trifle higher than the simple correlation with ΔU_{t-5} alone. When ΔP_{t-1} is included as another independent variable, i.e., assuming a distributed lag, the result is an R of .750, which is again only a little higher than the best of the distributed-lag equations with ΔU alone (compare the first and fifth lines). It may be objected that the application of a distributed lag to each of the two partial relationships involved should result in a more complex form with several lagged terms, but high intercorrelations of the independent variables thwart efforts to estimate the equations that would be yielded by this approach.[35]

Responses to Changes in New Orders

Since new orders are generally more variable than shipments (Chapter 3), fluctuation in ΔU often strongly reflects the fluctuations in N. This is not merely a matter of arithmetic: The underlying fact is that short-term changes in demand meet with lagged and partial adaptations of supply. Sufficiently large and long imbalances resulting from this process should give rise to adjustments of prices and delivery periods. Actually, price changes are positively associated with both levels and changes of deflated new orders, and so are the changes in the U/S ratio, which serve here as rough indicators of movements in average delivery periods.

[35] Assume that ΔP_t is a function of ΔU_{t-i} and of ΔQ_{t-j}; then, the use of the Koyck scheme would give here, in effect, two component lag distributions that result in a relationship in which ΔP depends on six terms: ΔU with leads of i and $(i + 1)$; ΔQ with leads of j and $(j + 1)$; and ΔP with leads of one and two periods. This is a "reduced equation" type of lag distribution obtained by a method worked out by Marc Nerlove, "Distributed Lags and Demand Analysis," *Agricultural Handbook No. 141*, U.S. Department of Agriculture, June 1958, pp. 25–31. An application of this form to the paper industry data gave coefficients with the expected signs (minus for the ΔQ terms, plus for the others), but also gave very large standard errors.

Table 7-5 lists the results of correlating ΔP_t with current or recent levels and changes of new orders (N, ΔN) and also of correlating $\Delta(U/S)_t$ with the same variables (columns 1 and 2). Multiple regressions with values of either N or ΔN for the current and previous quarters produce only small or even trivial improvements over the optimal simple correlations. There are substantial positive autocorrelations in the N series, much lower and generally negative autocorrelations in the ΔN series. The associations between the terms N and ΔN vary in sign and are rather weak. There are some gains from combining these terms, though they are quite modest. The most common timing in these equations is such as to imply positive effects upon ΔP_t of N_t and N_{t-1}, and negative effects of N_{t-2}.[36] In most cases, ΔP and $\Delta(U/S)$ are somewhat better correlated with N than with ΔN, which may appear surprising (see note 22, above). The explanation may lie partly in the relative measurement errors, which are presumably larger in ΔN than in N, and partly in the asymmetrical feature of the recent behavior of measured prices: The dominance of upward price movements is intensified in times of high demand, but comparable downward movements in times of low demand do not occur.

Comparatively high correlations between ΔP and the new-order variables are found in industries that face highly cyclical demand and produce either predominantly or in large part to order: nonelectrical machinery, transportation equipment (other than passenger automobiles), textile mills, and metalworking. The same industries also have relatively high correlations between $\Delta(U/S)$ and new orders. This suggests that there is considerable room for both price and backlog reactions in those areas of manufacturing where the flows of demand are particularly variable.

At the other extreme is the paper industry, with relatively stable flows of new orders and prompt output adjustments (see note 20). The average values of U/S are very low here, and price variations are large relative to backlog variations (Table 7-1).

The correlation statistics in Table 7-5, columns 1 and 2, yield very similar rankings of the industries: The Spearman coefficient is +.929.

We expect positive correlations between changes over time in prices and delivery period adjustments because p and k respond in the same direction to fluctuations in demand. However, such correlations would

[36] This is the implication of positive influences on ΔP_t of N_t and of $\Delta N_{t-1} = N_{t-1} - N_{t-2}$.

Table 7-5

Changes in Price and in Backlog-Shipment Ratios Correlated with Each Other and with Changes and Levels of New Orders, Quarterly, 1948–58

	Multiple Correlation Coefficients[b]		
Industry[a]	ΔP on N and ΔN (1)	$\Delta(U/S)$ on N and ΔN (2)	ΔP on $\Delta(U/S)$ (3)
Textile-mill products	.734	.762	.599
Nonelectrical machinery	.713	.665	.467
Primary metals	.580	.326	.163
Nonautomotive transport. equip.	.565	.631	.310
Fabricated metal products	.562	.403	.274
Other durable goods[c]	.483	.244	.443
Electrical machinery	.407	.239[d]	.162
Paper and allied products	.238	.061	.723

Source: Same as Table 7-1.

[a] Ranked by the correlations listed in column 1, from highest to lowest.

[b] In column 1, $\Delta P = P_t - P_{t-1}$ is used throughout; N_{t-1} is used for fabricated metals, electrical machinery, and paper; N_t, for the other industries. $\Delta N_t = N_t - N_{t-1}$ is used for other durable goods; $\Delta N_{t-1} = N_{t-1} - N_{t-2}$, for the other industries.

In column 2, N_t and $\Delta(U/S) = (U/S)_t - (U/S)_{t-1}$ are used throughout. ΔN_t is used for textiles, nonautomotive transportation equipment, and other durable goods.

In column 3, correlations of ΔP with $\Delta(U/S)_t$ and $\Delta(U/S)_{t-1}$ (changes in backlog-shipment ratios in the current and previous quarter) are used.

[c] Includes professional and scientific instruments; lumber; furniture; stone, clay, and glass; and miscellaneous industries.

[d] Coefficient of simple correlation between $\Delta(U/S)_t$ and N_t. Multiple correlation with ΔN added is not available, but it is not likely to be much higher. (Simple correlation between $\Delta(U/S)_t$ and ΔN_{t-1} is .176.)

be low if, say, price adjustments were sporadic and backlog adjustments were regular—or vice versa. They may be low, too, for those industries in which both types of reactions are weak because input flexibility is high and short-term fluctuations in quantities ordered can be met promptly by changes in the rates of output. Where changes in prices and delivery periods are generally small, it may be particularly difficult to separate their systematic components, which could still be well correlated, from the irregular components, which are not.

Consistent with this argument, the correlations between ΔP_t and current and preceding changes in the U/S ratios are all positive but not high (Table 7-5, column 3). In all but one case, these correlations are lower than those between ΔP_t and new orders, and they give a quite different ranking of the industries.[37] They also tend to be lower than the corresponding measures of the association between ΔP and ΔU (see Table 7-2, column 6), but the ranking of the industries in terms of these two sets of coefficients is similar.[38]

Buyers' Prices and Delivery Periods: Evidence from Diffusion Data

Data compiled by the Purchasing Agents Association (PAA) of Chicago provide at least a partial remedy for the two major shortcomings of our statistical results: (1) the reliance on seller-reported prices, which are unduly rigid in the short run, and (2) the reliance on indirect indicators of changes in the average delivery periods rather than on any direct measures.

The "vendor performance" index (D^*) is a monthly series of differences between the percentage of PAA survey members reporting slower and the percentage reporting faster deliveries to their companies by the suppliers (vendors).

The price series (P^*) is also a net diffusion index. It shows the differences between the percentage of PAA members reporting higher and the percentage reporting lower buying prices each month. While primary-market sellers tend to quote list prices, primary-market buyers would presumably use actual transaction prices or close approximations to such figures.[39] Hence, there is ground to expect that estimates based on purchasing agents' data will go far toward avoiding understatement of short-run price flexibility, an error that is likely to mar the results obtained from the BLS data.

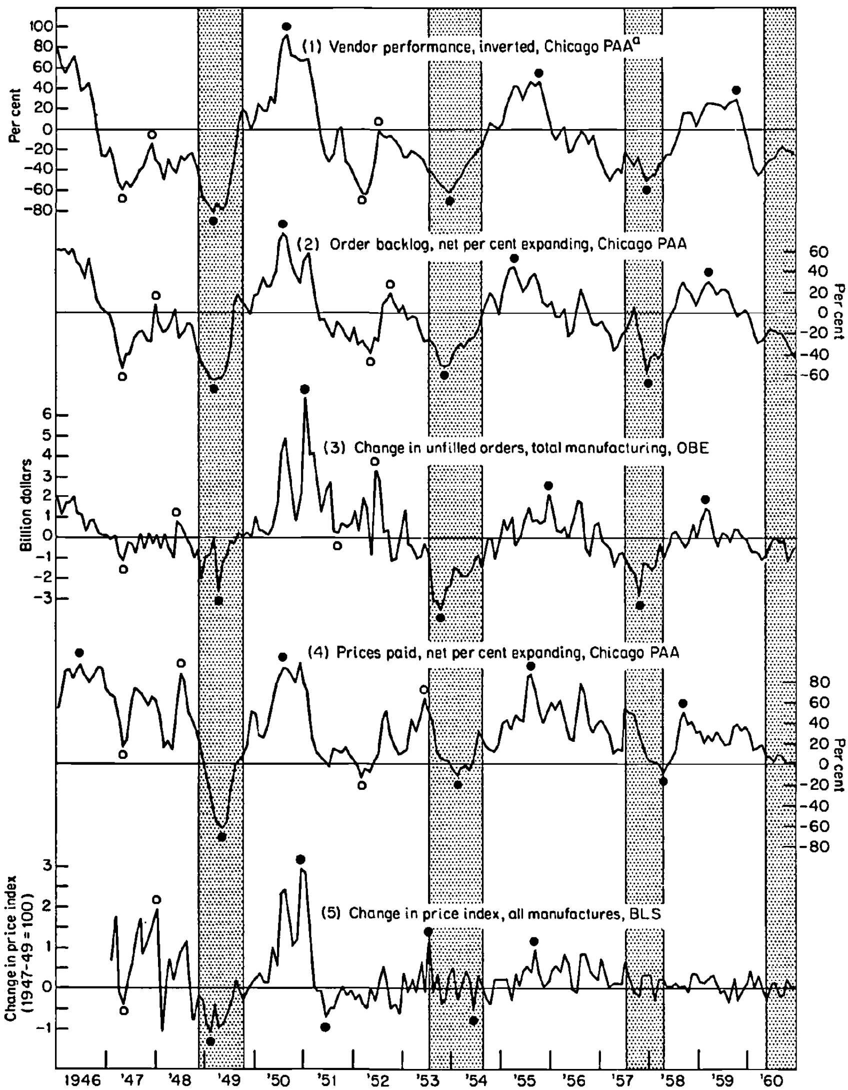
Chart 7-2 shows that the P^* index is, in fact, very sensitive to cyclical and other short-run influences. Certainly the index displays more

[37] Rankings based on the entries in columns 1 and 3 of Table 7-5 show a very low correlation (.119). The rank correlation coefficient for columns 2 and 3 is similar (.190).

[38] The rank correlation coefficient here is +.750. Statistically, the observed differences between these results in Tables 7-5 and 7-2 probably occur mainly because the U/S ratio series is much more erratic and much less cyclical than the corresponding U series. Measurement errors are likely to affect the ratio series more, and they could be quite troublesome when first differences in these series are used. For this reason, the measured correlations between ΔP and $\Delta(U/S)$ may significantly understate the actual association between changes in the average prices and delivery periods.

[39] See Harry E. McAllister, "Statistical Factors Affecting the Stability of the Wholesale and Consumers' Price Indexes," and Flueck, "A Study in Validity," both in *Price Statistics of the Federal Government.*

Chart 7-2
Diffusion Indexes of Delivery Periods, Order Backlogs, and Prices Paid, and Change in Manufacturers' Unfilled Orders and Prices, 1946–60



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

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

cyclical flexibility than does the all-manufactures price change series computed from the WPI figures (see series 4 and 5 in the chart). It is true that the index declined well below zero only in the 1949 recession, but in each of the three cycles before 1958 there were relatively large fluctuations of P^* that reached peaks as high as 80–90 per cent (the peak in 1958 was only about 50 per cent). In contrast, the cycles in the BLS price change series were relatively small and, particularly since 1952, obscured by more frequent and pronounced irregularities.

Inspection of the chart makes it clear that D^* and P^* are positively correlated (series 1 and 4). To reduce the disturbing effect of the short erratic movements, which are stronger in P^* than in D^*, both indexes were converted into quarterly form (by averaging the monthly data over nonoverlapping three-month periods), yielding sixty observations in 1946–60. Regression of these quarterly figures yields: est. $P_t^* = 113.5 + .544D_t^*$, with $r^2 = (.660)^2 = .436$. The two indexes are apparently approximately synchronous, with no systematic tendency for either of them to lead the other.[40]

A close association was found between the vendor performance index (D^*) and the diffusion of changes in the order backlogs (U^*), as reported by the Chicago PAA (series 1 and 2 in the chart). The correlation between monthly D^* and U^* is .934. Thus, there are parallel cyclical increases and decreases in the net percentages of returns reporting (1) longer delivery periods, (2) larger order backlogs, and (3) higher prices; but the relationship between (1) and (2) is much closer than that between either and (3). The increases in delivery periods and in unfilled orders are often less frequent than the decreases in these variables, but there are few periods in which price rises are less frequent than price declines.

The correlations between the quarterly diffusion indexes P^* and D^* are about the same (.6) as the simple correlations between the quarterly first-difference series ΔP and ΔU for paper, textiles, and other durables, but considerably higher than the corresponding results for the other industries (Table 7-2, column 5). Since the diffusion indexes appear to have a broad industrial coverage and to give large represen-

[40] When a lead of D^* relative to P^* of one quarter is assumed, a somewhat lower correlation (.611) results. But the former series is highly autocorrelated: The coefficient of correlation between D_t^* and D_{t-3}^* is .811. Correlating P_t^* with both D_t^* and D_{t-1}^* yields very little improvement [$R^2 = (.664)^2 = .441$]; the contribution of D_{t-1}^* is of low statistical significance.

tation to products of industries for which the correlations between ΔP and ΔU are low (e.g., metal products), there is some indication here that the measures based on the major-industry (OBE and BLS) series do understate price flexibility.[41]

It will be noted in Chart 7-2 that P^* is not only distinctly more cyclical but also less irregular than ΔP. The Chicago indexes, of course, may deviate considerably from the corresponding national series because of their regional origin. Moreover, even for the same aggregates, diffusion indexes and rates of change can differ significantly.[42] When all this is considered, the similarity in the cyclical change in the PAA backlog index and the first differences in the Commerce estimates of unfilled orders seems rather pronounced (series 2 and 3 in the chart). Most of the divergences between these series are due to the intensity of the irregular movements in backlogs. The coefficient of correlation between the PAA vendor performance index and the quarterly change in unfilled orders (series 1 and 3) is .692.

Wage Changes as an Additional Variable

Recent studies provide some examples of extreme emphasis on the dependence of short-run price behavior upon changes in costs. Sometimes, the influence of demand is excluded from explicit consideration.[43] This implies that changes in demand are met largely by backlog or stock adjustments. However, our regressions suggest that current or past changes in unfilled orders can account for a significant proportion of the variance of current changes in some industrial price indexes. Yet, it is also true that much of the price change remains "unexplained"

[41] However, this inference rests on the assumption that the PAA price index includes only fabricated or semifabricated items sold by manufacturers. (The BLS series presumably does satisfy this requirement.) Unfortunately, little information is available about the coverage of the PAA sample, and it was not possible to ascertain to what extent the price diffusion index (P^*) is indeed free of raw materials. We do know that the PAA series cover a broad range of industries but that they are, at least in one respect, more restricted than the OBE series. The former data cover manufacturers who supply industrial concerns; the latter, all manufacturers regardless of their role as suppliers.

[42] See Geoffrey H. Moore in Moore, ed., *Business Cycle Indicators*, Princeton for NBER, 1961, Vol. I, pp. 282–93.

[43] See, e.g., Joseph V. Yance, "A Model of Price Flexibility," *American Economic Review*, June 1960, pp. 401–18. Applied to U.S. tanning and shoe manufacturing industries, 1947–56, Yance's model incorporates a distributed lag of price change relative to changes in the cost of materials and average hourly earnings. The resulting R^2 coefficients vary between .41 and .75, with better fits being obtained from bimonthly or quarterly than from monthly data. The residuals of these regressions are generally autocorrelated, and Yance notes that "the autocorrelation may represent, in part, the effect of demand on profit margins . . ." and that "these demand effects are likely to persist from one month to the next . . ." (*ibid.*, pp. 411–12).

in these calculations. Let us ask, therefore, how much improvement can be achieved by allowing for the direct cost effects on price.

If a single cost variable is to be used, the best available choice appears to be the change in average hourly earnings as an approximation to the change in wages. The figures are easily derived from the monthly BLS data for five of the seven industries examined in Table 7-2. Let us denote the quarterly change in these gross hourly earnings by ΔW and assign to it the subscript "3" (ΔP and ΔU are the variables "1" and "2," respectively). Table 7-6 presents measures obtained from regressions of ΔP_t on (1) ΔU_t or ΔU_{t-1}, and (2) ΔW_t or ΔW_{t-1}. The measures are based on quarterly data for 1948–58.

I find that the inclusion of ΔW, while important in all cases, does not eliminate the influence of ΔU. In fact, price changes in paper and textiles are apparently more strongly affected by demand pressures as measured by ΔU than by the direct "cost push" (ΔW). The partial correlations of ΔP and ΔU, holding ΔW constant, exceed the simple correlations of the same variables and are considerably higher than the partials between ΔP and ΔW, holding ΔU constant (that is, $r_{12.3} > r_{12} > r_{13.2}$; also, $r_{12} > r_{13}$).[44] Compared with the distributed-lag regressions employing the ΔU's alone (monthly or quarterly), the present equations that include ΔW yield lower correlation coefficients for both textiles and paper (cf. the first two lines in Tables 7-2 and 7-6).

The influence of wage changes is relatively stronger in the regressions for the other industries. Thus, in nonelectrical machinery and in primary and fabricated metals, $r_{12} < r_{13}$ and $r_{12.3} < r_{13.2}$.[45] But the contributions of the ΔW's are not much more impressive here than those of the ΔU's; both variables together still do not explain more than between 40 and 50 per cent of the variation in ΔP. For nonelectrical machinery, the distributed-lag equation with monthly ΔU performs somewhat better than the present regression using quarterly ΔU and ΔW (the respective R^2 coefficients are .463 and .420).

It may perhaps be questioned whether the factors ΔU and ΔW should really be treated equally as potential determinants of price change. Since labor costs are an important part of price, it is only natural for the simultaneous changes in the two to be positively correlated. While

[44] The values of r_{12} and r_{13} are .714 and .463, respectively, for the paper industry and .679 and .481 for the textile industry.

[45] The values of r_{12} and r_{13} are .418 and .644, respectively, for primary metals; .471 and .612 for nonelectrical machinery; and .450 and .567 for fabricated metal products.

Table 7-6

Regressions of Price Changes on Changes in Backlogs and Wages, Five Major Industries, Quarterly, 1948–58

Industry [a] (1)	Independent Variables [b] (1)	Regression Constants (2)	Regression Coefficients [c] of ΔU (3)	ΔW (4)	Partial Correlation Coefficients [d] $r_{12.3}$ (5)	$r_{13.2}$ (6)	$R_{1.23}$ (7)
Paper and allied products	$\Delta U_{t-1}, \Delta W_{t-1}$	−0.609	.0314 (.0043)	58.826 (14.468)	.737	.518	.801
Textile-mill products	$\Delta U_t, \Delta W_t$	−0.615	.0061 (.0009)	76.768 (19.454)	.697	.525	.781
Primary metals	$\Delta U_t, \Delta W_t$	0.316	.0018 (.0007)	41.452 (7.733)	.348	.613	.696
Nonelectrical machinery	$\Delta U_t, \Delta W_t$	1.301	.0061 (.00038)	45.711 (10.525)	.271	.505	.648
Fabricated metal products	$\Delta U_{t-1}, \Delta W_t$	−0.287	.00213 (.00025)	58.508 (14.408)	.360	.510	.640

[a] Ranked according to the value of R in column 7, from highest to lowest.

[b] The subscripts identify the timing of ΔU and ΔW relative to the dependent variable, ΔP_t. The timing of ΔU follows the indication of Table 7-2, column 5. The regressions cover 43 quarters for textiles and fabricated metals, 44 quarters for each of the other industries.

[c] Figures in parentheses are calculated standard errors of the regression coefficients.

[d] ΔP, ΔU, and ΔW are variables 1, 2, and 3, respectively.

it is true that, at least in the framework of our short unit periods, it is easier to think of ΔW influencing ΔP than vice versa, the simultaneous relationship between the two variables must be presumed to contain some elements of a feedback. Thus, when prices rise because profit margins do, owing to strong and increasing demand for the product, wage increases may be demanded and rather promptly gained. Moreover, such demand pressures will often cause overtime work, and our wage-cost variable is computed from data which include overtime earnings. To avoid feedback difficulty, one could take the wage change with a lead relative to the price change, i.e., use ΔW_{t-1}, but this would drastically reduce the importance of the wage variable as a determinant of ΔP_t. Graphical analysis suggests strongly that the relation between ΔP and ΔW is simultaneous rather than lagged; this is confirmed in further computations.[46]

On the other hand, any feedback effect of ΔP upon ΔU is probably small. To be sure, actual price rises may induce expectations of further rises which stimulate advance buying. This would result in larger increases in both ΔU and ΔP, but it is consistent with the view that the increase in unfilled orders anticipates measured price increases rather than vice versa. A lag of ΔU relative to ΔP would imply that prices are often raised or lowered in anticipation of demand increases or decreases. But this does not appear to be common in the industries and periods considered here. Analysis of monthly data suggests that ΔU often precedes ΔP by short intervals, while the reverse sequence seems rather infrequent. Even when simultaneous quarterly values of the two variables are used, the treatment of ΔU as "given" or independent seems unlikely to be a source of any major errors.

Some Replications and Additions

Regressions of price change on deflated backlog change, analogous to those discussed above with the aid of Tables 7-1 and 7-2, have also been computed for some of the new Census series on unfilled orders and the current BLS wholesale price indexes. This analysis covers three industries—nonelectrical machinery, electrical machinery, and fabricated metal products—and employs monthly and quarterly data for 1953–64.

Such recalculations do not have the power of independent predictive tests, but they are certainly useful means of organizing additional evidence and of evaluating the closeness and stability of the relationships involved. The new data are, of course, akin to the old but are based on larger and presumably better samples (see Chapter 3, first section).

[46] Consider, e.g., the lowest-ranking industry in Table 7-6, fabricated metal products. Denote ΔW_{t-1} as variable "4" (ΔP_t, ΔU_{t-1}, and ΔW_t being represented by subscripts 1, 2, and 3, as before). Then $r^2_{14} = (.266)^2 = .051$; $r^2_{14.2} = (.045)^2 = .002$; $r^2_{12.4} = (.402)^2 = .162$. These results make it clear that ΔW_{t-1} bears virtually no relation to ΔP_t, especially when the effect of ΔU_{t-1} is taken into account. In contrast, the influence upon ΔP_t of ΔW_t was found to be significant, whether or not ΔU_{t-1} was included (see Table 7-6, last line, and note 45). The substitution of ΔW_{t-1} for ΔW_t also cuts in half the multiple correlation coefficient: $R^2_{1.23} = .410$, while $R^2_{1.24} = .205$. The only industry in our set in which ΔW_{t-1}, as distinguished from ΔW_t, seems to be of importance as a determinant of ΔP_t is paper (see Table 7-6, first line, and note 44).

Price changes in the current quarter (month) are positively correlated with backlog changes in each of the two preceding quarters (in each of the six preceding months). When ΔP and ΔU are taken with coincident timing (in quarterly or monthly terms), their correlations turn out to be positive for nonelectrical machinery and negative, but very low, for the other two industries. The simple correlations are generally lower than those reported in Table 7-2, which may be due to the greater stability of prices in the more recent period. The r coefficients for quarterly changes tend to be larger than those for monthly changes, probably because errors of measurement are reduced when the volatile monthly data are transformed into the smoother quarterly data.

In quarterly distributed-lag equations of Koyck form, the effects of ΔU are not suppressed by the generally strong influence of the autoregressive term ΔP_{t-1}, which is mildly encouraging. The regression results are as follows:

Fabricated metal products:

$$\Delta P_t = \underset{(.122)}{.256} + \underset{(.0099)}{.0268}\Delta U_{t-1} + \underset{(.136)}{.315}\Delta P_{t-1}; \; R = .463$$

Electrical machinery:

$$\Delta P_t = \underset{(.102)}{.064} + \underset{(.0056)}{.0082}\Delta U_{t-1} + \underset{(.123)}{.522}\Delta P_{t-1}; \; R = .593$$

Machinery, except electrical:

$$\Delta P_t = \underset{(.120)}{.305} + \underset{(.0196)}{.0298}\Delta U_t + \underset{(.121)}{.555}\Delta P_{t-1}; \; R = .608$$

The coefficients of the backlog terms, although small (fractions of index points per million dollars of change in ΔU), exceed their standard errors 1.5 to 3 times and are therefore probably significant. The addition of ΔP_{t-1} produces a relatively small increase in the correlation for fabricated metals but a large increase in the correlations for the two machinery industries.

The estimates suggest that reaction periods of 1.5 to 3.5 months are sufficient to account for about half or slightly more of the implied distributed-lag effects (fabricated metals would be close to the lower figure, the machinery industries close to the upper one). These are longer lags than those obtained for the Koyck equations of Table 7-2, but the use of quarterly rather than monthly data could work in this direction, and the differences in the implied lags seem of rather small importance. According to the replications, price changes are related to prior backlog changes, but the adjustments are small and the lags are rather short. The measures based on the older data, for the 1948–58 period, can be said to support the same general conclusions.

To what extent do these relations reflect the trends and fluctuations of the industrial sector of the economy as a whole and to what extent do they reflect developments that are specific to the particular industries concerned? In each of our equations, the dependent variable is an index showing changes in money prices rather than changes in relative prices. These indexes pertain to major industries and are therefore broad in coverage, but much less comprehensive than the over-all price-level indicators. General price movements depend on forces influencing the general level of economic activity, such as monetary changes and the over-all rate of capacity utilization or the relation between aggregate expenditures and supply, and relative prices depend on the conditions of particular markets and production processes. However, individual money price movements may reflect changes in the economy at large as well as more narrowly defined or local conditions. It seems plausible that the more comprehensive the money price index the greater should be the influence on it of general economic factors rather than particular ones.

The industry price indexes are indeed closely correlated with the price index for all manufacturing: the adjusted determination coefficients $\bar{r}^2$ are .973, .835, and .955 for fabricated metals, electrical machinery, and other machinery, respectively.[47] The industry backlog series show lower correlations with the unfilled orders series for total manufacturing: the $\bar{r}^2$ estimates here range from .752 to .881 for nonelectrical machinery and fabricated metal products, but are no larger than .118 to .308 for electrical machinery (the $\bar{r}^2$ coefficients are here larger for the monthly than for the quarterly series).

Positive but very low correlations exist in most cases between the residuals from these regressions (that is, between $u_t = P_{it} - a - bP_{mt}$ and $v_t = U_{it} - a' - b'U_{mt}$, where the subscript i denotes the industry series and m, the all-manufacturing one). The correlation coefficients

[47] These measures refer to quarterly data. For the monthly series, the $\bar{r}^2$ values are very similar: .972, .853, and .959.

for nonelectrical machinery and fabricated metals fall in the range of .3 to .4 for both the simultaneous relations between u_t and v_t and the lagged relations between u_t and v_{t-j}, $j = 0, \ldots, 3$ months. For electrical machinery, no significant associations are found between the corresponding residuals. Similarly, changes in relative prices $[\Delta(P_i/P_m)]$ show positive but low correlations with the changes in "relative backlogs" $[\Delta(U_i/U_m)]$. Only about one-tenth of the variance of $\Delta(P_i/P_m)$ can be accounted for in these regressions. The weakness of these relations suggests that any associations that can be found between the price and backlog changes (ΔP_t and ΔU_{t-j}) for the industries concerned must be attributed primarily to general developments in the economy rather than in the particular industry. These general developments, as defined by this analysis, are apt to be widely diffused and to account for a large proportion of changes in the major-industry series.

Quarterly data for 1953–64 also show that the lagged backlog changes ΔU_{t-1} still have net positive effects on P_t when the current wage changes, ΔW_t, are included in the regressions (as illustrated by the estimates below). In fact, the significance of the ΔU_{t-1} terms, as indicated by the t ratios, remains about the same or improves when the wage variable is added, except for nonelectrical machinery.

Fabricated metal products:

$$\Delta P_t = \underset{(.180)}{-.086} + \underset{(.0094)}{.0241}\Delta U_{t-1} + \underset{(7.671)}{24.640}\Delta W_t; \; \bar{R}^2 = .254$$

$$\Delta P_t = \underset{(.176)}{-.181} + \underset{(.0089)}{.0259}\Delta U_{t-1} + \underset{(7.320)}{23.461}\Delta W_t + \underset{(.123)}{.288}\Delta P_{t-1}; \; \bar{R}^2 = .324$$

Electrical machinery:

$$\Delta P_t = \underset{(.203)}{-.389} + \underset{(.0059)}{.0138}\Delta U_{t-1} + \underset{(9.942)}{32.448}\Delta W_t; \; \bar{R}^2 = .228$$

$$\Delta P_t = \underset{(.176)}{-.367} + \underset{(.0052)}{.0097}\Delta U_{t-1} + \underset{(8.784)}{25.514}\Delta W_t + \underset{(.116)}{.455}\Delta P_{t-1}; \; \bar{R}^2 = .422$$

Machinery, except electrical:

$$\Delta P_t = \underset{(.173)}{.078} + \underset{(.0054)}{.0077}\Delta U_{t-1} + \underset{(7.013)}{26.442}\Delta W_t; \; \bar{R}^2 = .250$$

$$\Delta P_t = \underset{(.156)}{-.054} + \underset{(.0048)}{.0051}\Delta U_{t-1} + \underset{(6.461)}{18.970}\Delta W_t + \underset{(.120)}{.449}\Delta P_{t-1}; \; \bar{R}^2 = .424$$

There are indications that ΔP is related to ΔU with lags: ΔU_{t-1} performs much better in these equations than does ΔU_t.[48] On the other hand, the relationships between ΔP and ΔW are mainly simultaneous ones, that is, the influence upon ΔP_t of ΔW_t is stronger than that of ΔW_{t-1}. However, even when both the wage changes and the autoregressive factor ΔP_{t-1} are included in the equations along with the lagged backlog changes, the over-all results, as judged from the $\bar{R}^2$ statistics, are only fair.[49]

Related Studies

To my knowledge, Thomas A. Wilson and I, independently, were the first to use unfilled orders in price adjustment models.[50] Wilson's informative paper deals with quarterly prices of machinery and steel in the period III-1953–II-1959. In addition to orders variables, $[(N-S)/S]_{t-1}$ and $(U/S)_{t-1}$, Wilson used changes in the wage index ΔW (based on average hourly earnings figures) and the deviations of GNP from its estimated trend values. For machinery, the regression coefficients were positive for all terms and significant for all except U/S. For steel, the coefficients of both order variables turned out to be negative and lacking significance.[51]

In his recent quarterly model of the U.S. economy,[52] Lawrence R. Klein related the price indexes for consumer durables and nondurables (p_d and p_n) to the general price level (p) and to manufacturers' unfilled orders of durable and nondurable goods in billions of 1954 dollars (U_d and U_n). The price indexes are implicit deflators for GNP and selected

[48] For nonelectrical machinery, ΔU_t appears to work somewhat better than ΔU_{t-1} in simple correlations with ΔP_{t-1} and also when taken along with ΔP_{t-1} (as in the equation at the beginning of the section, "Some Replications and Additions"). Yet here, too, ΔU_{t-1} is preferable to ΔU_t in regressions that include ΔW_t. However, in this case the net effects of backlog changes on price changes are quite weak.

[49] It would probably be easy to improve the correlations by adding, as another determinant of price movements, the changes in raw materials. Where materials have sensitive prices and are an important component of total costs, changes in their prices are likely to exert a strong influence upon the product price. It may be, too, that prices significantly lag costs but that the lengths are too short to be revealed by quarterly data. However, it must be recognized that the effect of changes in product demand upon input prices and the joint dependency of input and output prices can be just as important to material costs as to labor costs.

[50] Wilson, "An Analysis of the Inflation in Machinery Prices," Study Paper No. 3, Joint Economic Committee, 86th Cong., 1st sess., Washington, D.C., 1959. My first report on this work can be found in "Cyclical Behavior of Manufacturers' Orders," in *Investing in Economic Knowledge*, Thirty-eighth Annual Report of the National Bureau, New York, NBER, May 1958, p. 38.

[51] See Wilson, "An Analysis," App. Table 1, p. 67.

[52] "A Postwar Quarterly Model: Description and Applications," in *Models of Income Determination*, Studies in Income and Wealth, Vol. 28, Princeton for NBER, 1964, p. 18.

components, 1954 = 100. They are endogenous variables, while the unfilled orders for the two sectors of manufacturing are not.[53] Klein reports the following results:

$$p_d = \underset{(.034)}{.548} + \underset{(.039)}{.422p} + \underset{(.00017)}{.00067(U_d)_{-1}}; \bar{R} = 0.94$$

$$p_n = \underset{(.027)}{.346} + \underset{(.024)}{.618p} + \underset{(.0021)}{.00946(U_n)_{-1}}; \bar{R} = 0.97$$

In a recent article Eckstein and Fromm seek to explain changes in wholesale price indexes for all manufacturing and durable and nondurable manufacturing by combining cost variables—standard and actual unit labor costs and materials input prices—with demand variables, namely, the *U/S* ratio, deviations of the actual inventory-sales ratio from a twelve-quarter moving average of it, and rates of capacity utilization.[54] These specifications are intended to test both the competitive price determination model and the target-return pricing hypothesis.[55] Regression equations for quarterly first differences are shown to be preferable to those for levels and percentage changes. They show, for 1954–65, that the demand variables were nearly as important as the cost variables.[56] The industrial operating rate was more influential and significant than the backlog-shipment ratio, which Eckstein and Fromm found surprising, and which they attributed to the crude estimation of lags from quarterly data and the available price statistics; the inventory variable had no effect independent of the operating rate. The adjustment of prices to changes in demand and cost conditions appears to be rather prompt, the greatest part of it being completed within a few months.

Finally, in another recent paper,[57] T. H. Courchene, using Canadian data, finds quarterly changes in price indexes to be positively associ-

[53] However, *total* unfilled orders are endogenous in Klein's model. For a discussion of his equation for U_t, see below, Chapter 8, in section "The Supporting Equations for Orders in Recent Models of the Economy."

[54] Otto Eckstein and Gary Fromm, "The Price Equation," *American Economic Review*, December 1968, pp. 1159–83.

[55] *Ibid.*, pp. 1159–66; also, Otto Eckstein, "A Theory of the Wage-Price Process in Modern Industry," *Review of Economic Studies*, October 1964, pp. 267–86.

[56] This evaluation is based on sums of beta coefficients. Three to five cost variables (standard and actual, current and lagged) are included in these equations, as against two demand variables (the current capacity utilization rate and the lagged *U/S* ratio).

[57] "An Analysis of the Price-Inventory Nexus with Empirical Application to the Canadian Manufacturing Sector," *International Economic Review*, October 1969, pp. 315–36.

ated with new and unfilled orders for several major manufacturing industries that produce largely to order. He uses unlagged levels, rather than changes in orders, which may be the reason he gets better results with another proxy for "excess demand," namely, deviations of actual from equilibrium inventories (where the latter are regression estimates which do incorporate the effects of current and lagged orders).

Summary

Changes in unfilled orders are associated with planned and unplanned changes in delivery periods. Speedups of delivery often raise costs to the producer; delays, costs to the buyer. Other things being equal, therefore, an inverse relation between price and delivery period is to be expected. However, if demand increases give rise to pressures upon the industry's capacity to produce, the result may be both backlog accumulation associated with a lengthening of the average delivery lags and an increase in prices of the affected products.

Unpredictable fluctuation in demand is probably a central phenomenon behind the large volume and wide swings in unfilled orders. The hazards of uncertainty are large for a manufacturer who would rely only on pricing policy to meet such changes, and so are the requirements of information. Letting backlogs accumulate and decumulate would often be seen as less risky and less demanding. However, noncompetitive behavior or restrictions on the competition in product and factor markets may act in the same direction, as reinforcing forces.

The assembled evidence is generally consistent with the hypotheses presented. Changes in the price index for a given industry's products (ΔP) are positively correlated with changes in that industry's unfilled orders (ΔU). Since $\Delta U = N - S$, systematic movements in this variable (expressed in constant prices) may be viewed as indicative of systematic changes in quantities demanded relative to quantities supplied. It seems plausible that prices should react primarily to the more persistent variations in the demand-delivery conditions, and this is partly confirmed, e.g., quarterly regressions of ΔP on ΔU give better results than monthly regressions. However, the gains from replacing discrete lags by distributed lags in these models often proved to be small.

Both price changes and average delivery-period changes [represented by $\Delta(U/S)$] are positively correlated with fluctuations in quantities demanded (new orders in real terms). Relatively high correlations of N and ΔN with both ΔP and $\Delta(U/S)$ are observed for several industries with highly variable flows of new orders. In contrast, the correlations are very low for products which face relatively stable flows of demand and which are subject to prompt output adjustments. Positive correlations also exist between ΔP and $\Delta(U/S)$, but they are generally quite weak, partly for economic and partly for statistical reasons.

The greater the importance of production to order and the longer the average delivery lag, the greater the role of backlog reactions compared to price reactions. Thus, when the industries are ranked according to the coefficients of ΔU in the regressions of ΔP on ΔU, a high inverse correlation is obtained between these ranks and rankings by average U/S ratios for the same industries.

Changes in wages (average hourly earnings), ΔW, are positively correlated with changes in prices when quarterly series with simultaneous timing are used. This would be expected, of course, since labor cost is typically an important component of price; the relationship between these variables may contain substantial elements of interdependence rather than being limited to one-way causation from ΔW to ΔP. On the other hand, there are indications that ΔU leads ΔP; and there are still significant net effects of ΔU upon ΔP in regressions that also include ΔW.

Diffusion indexes based on surveys of purchasing agents provide independent, confirming evidence that changes in unfilled orders and delivery periods are directly and closely associated and that both tend to agree in direction with changes in transaction prices.