Changes in Inventory Management: Implications for the U.S. Recovery

Jane Sneddon Little

Economist, Federal Reserve Bank of Boston. *The author has benefited a great deal from the comments and suggestions of several colleagues, but particularly Richard W. Kopcke and Jeffrey C. Fuhrer. Lawrence D. Herman, Michael D. Jud, and Garrett J. Solomon provided excellent research assistance. The author is particularly grateful to Michael Jud for his substantive contributions to the statistical work.*

Throughout the recent recession and ensuing period of barely perceptible growth, manufacturers have described their inventories as remarkably lean. Since inventories usually rise sharply relative to sales during economic downturns, these manufacturers have hastened to add, with some pride, that their well-controlled stocks result from considerable management effort. Many of these firms reportedly changed their approach to inventory management during the 1980s. Sometimes these efforts required substantial investments to install new systems; often the effort is considered incomplete.

A glance at inventory-to-sales trends supports these manufacturers' claims about the ratios' "historically" low levels—by recent standards, at any rate. Thus, even though inventory accumulations and liquidations typically aggravate business cycles,[1] early in the recent downturn many observers suggested that these unusually lean inventory-to-sales ratios would insure a rapid and robust recovery from a short, mild recession. In the event, these observers have been disappointed in the nature of the recovery.

Despite media commentary and manufacturers' protestations, many analysts remain skeptical that the relationship between inventories and sales has changed significantly once, for example, differences in the outlook for inflation are taken into account. And, indeed, much current research has uncovered little evidence of any structural change. For example, in a relatively recent review of the inventory literature, Alan Blinder and Louis Maccini address the issue by saying that "despite the alleged revolution in inventory practices brought about by computerization, the economy-wide ratio of real inventories to real sales has been trendless for 40 years" (1991, p. 75).[2] Similarly, in discussing the trend toward more frequent deliveries from U.S. auto suppliers to assemblers, Womack, Jones, and Roos of MIT's International Motor Vehicle Program describe the change as "simply an attempt by assemblers to shift costs to their suppliers," with little net reduction in

inventories for the U.S. industry as a whole (1990, p. 160).[3] These differing conclusions may simply reflect different perspectives, since individual firms or industries could make major strides in reducing their own inventory-to-sales ratio without the economy as a whole achieving significant savings in required stocks.

This article begins by describing recent trends in inventory management at the firm level. It then presents statistical evidence supporting the manufacturers' claims that something is different. During the 1980s a structural change in the relationship between inventories and sales does seem to have occurred, most noticeably within the manufacturing sector, but also in the economy as a whole. A final section explores the implications of these structural changes for the pace of current economic growth. Since initiatives to reduce inventories both reflect and permit greater efficiency, in the long run they suggest enhanced U.S. economic welfare. Nevertheless, contrary to the optimists who thought that tight inventories implied a robust recovery, this article will argue that the *transition* to improved inventory management is exerting a noticeable drag on current economic growth. In addition to providing evidence that a structural change is under way, this article also presents indications that the transition is not yet complete. Accordingly, the article concludes by speculating that the ongoing adoption of lean inventory practices represents a structural impediment to a rapid recovery.

This article will argue that the transition to improved inventory management is exerting a noticeable drag on current economic growth.

Setting the Stage: Why the 1980s?

Pushed by increased competition and pinched profit margins and aided by the falling cost of new technology, most U.S. firms in manufacturing and trade made some effort during the 1980s to reduce the resources devoted to holding and handling inventories. One contributory development was the sharp rise in real interest rates from historically low levels in the late 1970s to much higher levels in the early 1980s. Because high real interest rates increase the cost of holding inventory, this change undoubtedly encouraged firms to find ways to eliminate excess stocks. In addition, between 1980 and 1985, the dollar appreciated by 50 percent in the foreign exchange markets. This appreciation exposed U.S. producers to greatly increased foreign competition, again forcing them to reexamine their operating methods. At the same time, the availability of small computers and other information processing technology was exploding, while the real cost of this equipment was declining rapidly. In other words, during the 1980s incentive and opportunity converged to persuade U.S. businesses to find new ways to manage their inventories.

Undoubtedly because the Japanese auto firms had grabbed U.S. market share during the oil crises of the 1970s and then, in 1982, began setting up competing plants onshore, U.S. auto companies made some of the first moves towards adopting new methods of inventory control. In 1984, for example, General Motors and Toyota opened the New United Motor Manufacturing Inc. (NUMMI) plant in Freemont, California. This joint venture typified the U.S. auto industry's somewhat scattered efforts to experiment with Japanese lean production methods in the United States (Womack, Jones, and Roos 1990). (See the Box for a brief description of "lean manufacturing," as developed at Toyota.)

Wholesalers and retailers appear to have focused on inventory reduction somewhat later than manufacturers, even though the trade sector almost tripled its investment in information processing equipment[4] between the late 1970s and the early 1980s (Hender-

[1] In the United States, but not necessarily in Japan. See West (1991).

[2] The 40-year period seemingly covered the years 1949 to 1989. In another recent study finding no evidence of structural change, Kenneth D. West wrote, "But over the longer 1967–1987 period, we see . . . that there has been no secular movement in any of the (inventory-to-sales) ratios in the U.S." (West 1991, p. 9).

[3] By contrast, two recent papers that do find evidence that the inventory-to-sales (or output) ratio has declined over time or with the advent of computerized inventory control are Cuthbertson and Gasparro (1992), who looked at data for the United Kingdom, and Bechter and Stanley (1992), who found clear evidence of improved inventory control in U.S. manufacturing but mixed results in wholesale and retail trade.

[4] Information processing equipment covers everything from cash registers to computers to point-of-sale scanning equipment.

Lean Production

The lean approach to manufacturing was developed in the 1950s at Toyota by Eiji Toyoda and Toyota's chief production engineer, Taiichi Ohno, in response to conditions in post-World War II Japan. At that time, the Japanese auto market was small, the Japanese manufacturers had little capital, and the American occupation forces greatly restricted management's right to lay off workers. Because Ohno's capital budget required that most of a car be stamped from just a few press lines, he developed simple die-change techniques that permitted production workers to change dies every two or three hours in a process that took three minutes. In the United States, by contrast, presses were plentiful and dedicated to specific tasks, and die changes were made only every few months or years by die change specialists who usually took a full day to make the switch.

Forced by their lack of capital to rely on just a few presses, Ohno then discovered that producing small batches of stampings actually saved money. Making small batches eliminated the cost of carrying huge inventories of work in process, and making only a few parts before assembling them into finished cars caused stamping mistakes to show up right away.

Other hallmarks of lean production include asking teams of workers to take responsibility for spotting and correcting quality and other problems and for suggesting ways to improve the production process. Lean supply is another key ingredient. In lean supply, assemblers and suppliers work together to lower costs and improve quality. Indeed, first tier suppliers participate in the design of new products. In addition, the flow of parts between suppliers and assembler is coordinated so that the supplies arrive "just-in-time." The signaling mechanism is the container carrying parts. When the parts are used up, the container returns to the supplier, thereby signaling the need for more parts.

son 1992). Indeed, it was not until a 1987 canoe trip that Wal-Mart's Sam Walton and Procter & Gamble executive Lou Pritchett realized that their companies had been communicating "by slipping notes under the door. . . . No sharing of information, no planning together, no systems coordination. We were simply two giant entities going our separate ways, oblivious to the excess costs created by this obsolete system" (Walton 1992, p. 186).

Shortly thereafter, Procter & Gamble and Wal-Mart managers developed an innovative system for exchanging sales and inventory data via computer. According to Mr. Pritchett, "We broke new ground by using information technology to manage our business together, instead of just to audit it" (Walton 1992, p. 187). Since then, Wal-Mart has used this relationship as a model and has pressed other suppliers to adopt electronic data interchange (EDI) as well.

Accordingly, the years 1982 and 1987 seem to bracket the start of serious efforts to eliminate waste in U.S. inventories. In 1982 the arrival of Honda with the first Japanese transplant caught the U.S. manufacturers' attention, while Sam Walton and Lou Pritchett's 1987 canoe trip led to major changes in retailing and in the supply system linking the two sectors.

New Approaches to Inventory Management

Manufacturers have taken a variety of approaches to cutting inventories, with varying degrees of success. Some firms have focused on inventory reduction directly; in other cases, declines in the inventory-to-sales ratio have accompanied efforts to implement a quality or time management program or a move toward lean production. Wherever the emphasis has been placed, quality, time, and inventory behavior are clearly closely connected. Just as operating with slim inventories requires promptly delivered parts with few defects, so, conversely, high-quality production reduces inventories of work-in-process.[5]

[5] How important reducing defects can be is illustrated by Toyota's savings. Typically, U.S. mass-production auto plants devote 13 percent of their space to the rework area and up to a quarter of the total hours required to build a car to fixing mistakes. By contrast, Japanese assembly plants currently use 4 percent of their space and almost no time at all for rework (Womack, Jones, and Roos 1990, p. 92).

Manufacturing

Manufacturing approaches to inventory control tend to fall into two categories that are often viewed as alternatives but can in fact be combined to advantage.[6] More widely used in this country is materials requirements planning or materials resource planning (MRP or MRPII), a computer-driven system which initiates production in anticipation of forecast demand. By contrast, just-in-time (JIT) starts production in reaction to current conditions on the shop floor. As an example of the difference, McDonald's runs a JIT shop, while a caterer must use an MRPII-type system. Like MRPII, just-in-time aims to deliver whatever is needed when it is needed; it seeks to eliminate delays and confusion and to save the resources that would otherwise be devoted to storing and moving excess work-in-process or buffer stock. But, JIT does not recognize future events.

By contrast, MRP starts with expected sales and releases orders for the required parts according to predetermined lead times. Relative to JIT, MRP is expensive, since companies must purchase the computer systems on which the approach is based and train workers to use them. In addition, the system's assumption of fixed (but adjustable) production methods and lead times contrasts with the JIT focus on constant improvement.

JIT works best when demand is smooth; when demand varies, JIT is less likely than MRP to operate in a stockless manner. Long before JIT was widely known in this country, Forrester (1961) had already shown that the more variable the demand conditions, the more inventory a distribution system needs. Indeed, the current slowdown in Japanese economic activity may expose the Japanese JIT system to unusually severe stress.[7]

The Retail Equivalent

The retailers' equivalent to MRPII or JIT is Quick Response, a business strategy intended to cut the costs associated with managing inventory, while reducing stockouts and improving customer service. According to an Andersen Consulting study, in 1988 some 36 percent of U.S. vendors of general merchandise were using the Universal Product Code, a first step in implementing a Quick Response Program, while just 10 percent of the survey respondents were exchanging data electronically to some degree (Andersen Consulting 1988). Three years later, Andersen Consulting found, almost three-quarters of Florida retailers were "in the process of" implementing Quick Response in their operations (*Chain Store Age Executive* 1991). Nevertheless, as the same issue of *Chain Store Age Executive* points out, while most retailers have begun to install Quick Response technologies, few have established the vendor-supplier partnerships required to shorten the inventory pipeline significantly, probably because such strategies require difficult cultural changes. As an example of such resistance, it took Federated Department Stores' bankruptcy to get its divisions to cooperate in developing a centralized inventory management system. The eight divisions had long opposed such a step as largely useless, since each chain has its own personality and market niche (Strom 1992).

Few retailers have established the vendor-supplier partnerships required to shorten the inventory pipeline significantly.

The new technologies that permit Quick Response include bar coding and point of sale scanning, which allow retailers to track merchandise to the item-size-color level, and electronic data interchange (EDI), which permits retailers and suppliers to share sales data and business documents. These technologies let retailers increase checkout productivity, reduce stockouts and markdowns, and end the need to reprice merchandise for promotions. They also improve distribution center productivity by eliminating manual receiving and checking procedures. In addition, automatic replenishment systems can continuously compare inventory, order-to-delivery time lags, and expected sales to generate purchase orders for specific stores and items. EDI speeds the flow and increases the accuracy of such transactions as pur-

[6] Much of this section is based on Karmarkar (1989).

[7] Heretofore, whenever the Japanese auto makers have faced a decline in domestic demand, they have maintained relatively smooth output growth by expanding exports (Womack, Jones and Roos 1990). This slowdown may be the first in which international politics and the Japanese auto makers' competitive position will not permit this solution. Accordingly, Japanese assembler-supplier relations are showing unusual signs of strain (Pollack 1992). Perhaps the Japanese will want to incorporate elements of MRPII into their JIT systems.

chase orders, advanced shipping notices, and invoices. This type of communication between retailers and suppliers reduces clerical, data entry, postage, handling, and form printing costs, while improving accuracy. It also reduces inventory lead times and carrying costs. As Forrester has shown, reducing delays can actually cut the amount of inventory needed for the pipeline.

Accomplishments of Individual Firms

What have firms introducing these new approaches to inventory management accomplished? This section provides a small sample of individual company experiences. Its aim is to suggest by anecdote that companies trying to reduce the resources devoted to holding and handling inventory have succeeded in reaping some significant savings.

In 1982 Xerox began to feel increased pressure from Japanese competitors and was losing market share. At that time, the company was buying materials representing 80 percent of its manufacturing costs from 5,000 suppliers. Seeking to reduce these costs, the company narrowed its supplier base to 400 and began training the selected suppliers in statistical process and statistical quality control programs and just-in-time manufacturing techniques. Xerox also included suppliers in the design of new products. As a result, from 1981 to 1984, net product costs were reduced by close to 10 percent a year, rejects of incoming materials were reduced by 93 percent, and production lead times were reduced from 52 weeks to 18 weeks (Burt 1989).

Similarly, in 1986 Northern Telecom Inc. decided to improve its competitiveness by "squeezing time" out of its operations. Using a quality management program, the company reduced manufacturing intervals by two-thirds. In the area of procurement, it installed a JIT inventory system on the shop floor and worked closely with "certified," single-source suppliers to make sure that the materials received meet Northern Telecom's quality standards and arrive on time. As a result, at the Research Triangle Park Division, which makes large digital central office switching systems, the receiving cycle has been cut from three weeks to four hours, the incoming inspection staff has fallen by half, and shop floor problems caused by defective materials have almost vanished (Merrills 1989).

Looking abroad, Unipart, a British auto part maker, adopted lean manufacturing methods and increased inventory turnover from three to four times a year to 27 times a year. Stocks of parts and finished products once occupied 80,000 square feet; they now occupy 28,000 square feet, a 65 percent reduction ("Unipartners" 1992). More widely, auto parts suppliers using a lean approach report declines of as much as 50 percent in the amount of space required for production and increases in productivity as high as 30 percent (Womack, Jones, and Roos 1990). (For additional examples, see the Box on page 42.

Of course, these examples reflect the efforts of just a few companies that have embraced lean manufacturing with enthusiasm and success. What has happened in the economy as a whole?

The Broader View

Looking at Figures 1 and 2, which show inventory-to-sales ratios for the major sectors of the economy, suggests that something may have "happened" in the 1980s. (Appendix Figures A-1 through A-3 provide a more detailed picture.) Since the end of 1982, this ratio has fallen—modestly for the economy as a whole, sharply for durable goods manufacturing.[8] By exception, retail inventories trended up slightly, but not enough to offset all of the gains made in manufacturing. The charts also show that while inventories jumped up slightly in relation to sales during the recent recession, the ratio did not continue climbing throughout the downturn as has been the norm in previous cycles. Indeed, in manufacturing and trade, the inventory-to-sales ratio averaged just 1.46 during the recent recession, only slightly above the low point of 1.44 reached briefly in the nonrecessionary first quarter of 1973. In the first quarter of 1991, the inventory-to-sales ratio was 1.49, 10 percent below its average for the four previous cyclical troughs.

But do these changes necessarily reflect the efforts to cut inventories discussed above? After all, the recent recession was relatively mild, by official stan-

[8] Inventories can be divided into five roughly equal parts. Retail and wholesale inventories each account for one-fifth of the total and are largely composed of finished goods. The three-fifths of the total represented by manufacturing stocks are fairly evenly divided between materials and supplies, work-in-process, and finished goods. During the 1980s, these three types of manufacturing inventories declined proportionately. This development should help to convince doubters that the economy could have made at least modest net reductions in inventories, since cutting work-in-process is fundamentally different from shifting stocks to and fro in the supply chain.

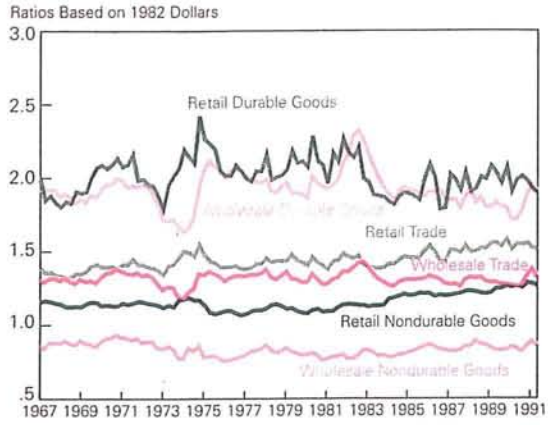
Figure 1

Inventory-to-Sales Ratios Manufacturing and Trade, and Manufacturing

Quarterly data, seasonally adjusted.
Shaded areas represent recessions.
Source: U.S. Bureau of Economic Analysis.

Figure 2

Inventory-to-Sales Ratios in Wholesale and Retail Trade



Quarterly data, seasonally adjusted.
Shaded areas represent recessions.
Source: U.S. Bureau of Economic Analysis.

Further Examples of Individual Firm Accomplishments via Lean Inventory Management

As another example of individual company efforts, in 1987 Hewlett-Packard was receiving just 21 percent of its deliveries on time. The firm spent many hours devising schemes to keep production lines operating in the face of delays, while early deliveries required costly storage and control. Unclear communications turned out to be one of the main problems; the supplier did not always know whether the date on the purchase order was the shipment date or the delivery date. Accordingly, Hewlett-Packard began using electronic purchase orders that flow directly from HP's computers to the suppliers' open-order management systems. Two years later, 51 percent of deliveries were on time. As a consequence the production line stops less frequently, and inventory expenses are down (Burt 1989).

Very recently, NCR-Ithaca (New York), in the computer printer industry, used JIT methods to cut on-hand inventory from 110 days to 21 days. Work-in-process was cut by 80 percent (Saxonhouse 1991). And, according to an April 1992 press release, Kaye Instruments of Bedford, Massachusetts implemented a full MRP system in 1991 and reduced net inventory by one-third while increasing shipments by 7 percent.

Finally, in the retail sector, Designs Exclusively Levi Strauss & Company, an apparel chain based in Chestnut Hill, Massachusetts has established a Quick Response-EDI partnership with its one vendor, Levi Strauss. The chain provides Levi Strauss with a frequently adjusted desired stock level for each item (including size and color) and a weekly sales data file. Levi Strauss compares sales with desired stock levels and automatically sends replenishments direct to each store. The chain's chief financial officer estimates that this system has reduced inventories by as much as 15 percent while stockouts have declined dramatically (*Chain Store Age Executive*).

dards, while expected inflation has declined markedly over the decade. Other constraints equal, rapid inflation is generally thought to encourage higher inventories, because firms may be able to buy or build now and sell later at a higher price. In such an environment, the difference between the purchase and selling price may more than offset the cost of carrying the inventory. Moreover, as mentioned previously, carrying costs, as measured by real interest rates, soared in the early part of the decade, thereby providing another incentive to reduce stocks.

The Model

This study uses a set of simple regressions and statistical tests to see whether the new inventory management technologies have actually contributed to the apparent reduction in the inventory-to-sales ratio to a statistically significant extent. The model tested is a relative of that commonly used in economic studies, except that here the dependent variable is the inventory-to-sales ratio, whereas most studies seek to "explain" inventory investment.[9]

As is the case in these related models, the constant-dollar inventory-to-sales ratio at the end of a given quarter is assumed to be positively related to its value at the end of the previous quarter; because the inventory-to-sales ratio appears to adjust to changes in economic conditions rather slowly, the higher the ratio in one quarter, the higher its value is likely to be in the following period.[10] Similarly, because inventories change more slowly than sales, the inventory-to-sales ratio is expected to have a negative relationship with the growth in sales in recent quarters. That is, the faster sales were growing in the previous three quarters, the lower the current inventory-to-sales ratio is likely to be. Unexpected changes in the growth in sales, measured in this article by the growth in the current quarter minus the growth in the previous period, also contribute to unplanned changes in stocks; thus, a slowdown in the pace of sales in the current quarter is expected to lead to an increase in the inventory-to-sales ratio.[11]

Inventory behavior is also believed to reflect inflationary expectations and the cost of carrying inventories. Previous investigators have determined that these variables should enter the equation separately rather than combined in the form of the real interest rate. (See Akhtar 1983, for instance.) One reason for this strategy is that current carrying costs (represented by nominal short-term interest rates) are known precisely by corporate decisionmakers and clearly (theoretically, if not empirically) have a negative relationship with a firm's desire to hold stocks. By contrast, future inflation must be estimated and is likely to show a positive association with building inventory, as mentioned above.[12] In this study, the change in the short-term interest rate from the previous to the current quarter performed better than the

[9] Blinder and Maccini (1991) provide a thorough review of the economic literature.

[10] In the economics literature, much attention is devoted to the plausibility of the surprisingly long inventory adjustment periods found in most empirical studies. Since the entire adjustment required usually amounts to a couple of days' output, it may seem puzzling that the adjustment appears to get stretched out over several months. However, in his 1961 textbook, Jay Forrester pointed out that the more gradually a producer adjusts actual inventories to desired levels, the less production variability the firm will experience.

Forrester also addressed another issue that has puzzled many economists: why output is more variable than sales when producers hold inventories for "production smoothing" purposes. As Forrester explains, producers and retailers set targets or limits for inventories. The lower limit is set to avoid halting the production line or allowing stockouts; space constraints determine the upper limit. Accordingly, even though sellers use inventories to absorb an initial demand shock, production will still be more variable than sales, because all the players along the supply chain will adjust their reorder rate to meet the new level of demand *as well as* to restore their inventories to desired levels. In general, the longer the time delay between final sale and replacement production or the more complex the pipeline, the greater will be the variability in production vis-à-vis sales.

[11] While modeling expected and unexpected changes in sales always presents challenges, the approach used in this article is admittedly not completely orthodox. Cuthbertson and Gasparro (1992), for example, use a variance rather than a difference to measure unexpected changes in output (sales). Moreover, equations explaining inventory *investment* often use lagged changes in sales to represent sales expectations. In this paper, looking at the inventory-to-sales *ratio*, however, the coefficient on the distributed lag of changes in sales in the previous three quarters appears to reflect the relatively slow pace of adjustment to changes in sales rather than a change in expectations. Still, because of doubts about whether current quarter changes in sales really represent surprises, Appendix Table A-3 presents the results of regressions in which expected sales, modeled following Bechter and Pollock (1981), were included in the equation. On the whole this forward-looking model produced results similar to the backward-looking model presented in the text. In particular, investment in information processing equipment generally has a significant negative link to the inventory-to-sales ratio. In addition, the coefficient on unexpected changes in sales (the change in sales during the current quarter) usually remains significantly negative even when expected sales are included. Nevertheless, because the backward-looking equations "behaved" better as a whole, as was true for Cuthbertson and Gasparro as well, the backward-looking equations appear in the text, while the forward-looking equations are relegated to the Appendix.

[12] As will be discussed further below, however, work in process is likely to have a negative link with inflationary expectations. In addition, retailers appear to follow a different purchasing strategy from that pursued by manufacturers.

level of the interest rate.[13] Expected inflation is represented by the pace of core inflation over the previous year. More sector-specific measures of price change tended to perform less well.[14]

Finally, and key for the purposes of this article, the ratio of investment in information processing equipment to GDP, in 1982 dollars and lagged four quarters, represented technological changes permitting new approaches to inventory management.[15] Although JIT systems do not require investment in computers and scanners, interest in these organizational approaches seemed to coincide, at least roughly, with growing use of equipment-dependent techniques like MRPII or Quick Response. For example, "just-in-time" first appears as a separate entry in the periodicals indexes in 1984. The most obvious alternative to this approach, using a time trend or a time trend with a dummy after the end of 1982, is difficult to interpret and less defensible. (That course did, however, produce roughly similar results, as shown in Appendix Table A-4.)

This model was applied to quarterly data from 1968:I to 1990:IV. In addition, the same regressions were run with the data divided into two subperiods, 1968:I to 1982:III and 1982:IV to 1990:IV, in order to test whether structural changes have occurred. The year 1982 was chosen as the dividing point because of the behavior of the time series and because of pivotal events like the establishment of the Honda plant and the appearance of JIT in the periodicals indexes.

Table 1
Regression Results, Manufacturing and Trade

	1968:1–1982:3	1982:4–1990:4	1968:1–1990:4
C	.36	.74	.33
	(6.88)	(3.09)	(6.52)
Lagged Dependent	.77	.58	.80
	(22.48)	(4.70)	(24.86)
Information Processing Investment/GDP (−4)	.00065	−.03511	−.00801
	(.13)	(−3.11)	(−4.98)
Change in Interest Rate	−.00309	−.00019	−.00260
	(−3.04)	(−.07)	(−2.80)
Inflation	.00103	.00466	.00188
	(1.18)	(.96)	(2.32)
Unexpected Sales	−.00594	−.00464	−.00595
	(−8.34)	(−2.32)	(−9.80)
Percent Change in Sales[a]	−.014	−.018	−.012
	(−9.35)	(−3.45)	(−8.15)
Rho[b]	.00	.30	.30
	(.00)	(1.32)	(2.65)
Durbin Watson	1.96	1.90	2.03
Adjusted R2	.974	.961	.962

[a]Polynomial Distributed Lag (first degree polynomial, 3 quarters including current quarter, far endpoint constraint). Coefficients shown are the sum of the lagged coefficients.

[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.

T-statistics in parentheses; critical value = 1.993 at the 5% level.

Regression results for other industries are shown Appendix Table A-1, along with definitions and sources.

The Results

Because increases in the inventory-to-sales ratio in one industry or sector could offset decreases in others, the key regression result for macroeconomic purposes is that for manufacturing and trade. Accordingly, Table 1 shows the results for manufacturing and trade alone while the results for the major subsectors and 15 individual industries are presented in Appendix Table A-1.

In general, the explanatory variables have the expected signs and are statistically significant at the 5 percent level for the economy as a whole, for manufacturing and durables and nondurables manufacturing, and for many of the individual manufacturing industries. The variables that tend to be insignificant are usually inflationary expectations or the change in interest rates, variables notorious for misbehaving in inventory models. (See, for example, Blinder and Maccini 1991, p. 82.) Most important for the focus of this article, however, investment in information pro-

[13] The interest rate on three-month CDs in the secondary market was used for the regressions even though the commercial paper rate better represents corporate borrowing costs. Unfortunately, commercial paper rates are not available back to the 1960s. However, the two interest rate series are very closely correlated once they can be compared.

[14] A measure of corporate financial flexibility, such as the ratio of current assets to current liabilities, also ought to have a positive relationship with the inventory-to-sales ratio; the more flexibility, the less the need to reduce inventory to free up cash. Moreover, the less financial flexibility a firm has, the more important interest rates are likely to be in determining the inventory-to-sales ratio. While Cuthbertson and Gasparro (1992) found a positive relationship with a measure of leveraging (in the absence of any measure of real interest), the regressions conducted for this study uncovered a significantly positive link between the current ratio and inventory behavior in just a few cases.

[15] Cuthbertson and Gasparro (1992) use the stock of information processing equipment as an explanatory variable in their study of the behavior of inventory investment in Britain.

cessing equipment appears to have a statistically significant negative relationship with the inventory-to-sales ratio for the economy as a whole and for most of the manufacturing sector for the entire period (1968:I to 1990:IV) and for the more recent years (1982:IV to 1990:IV). The only manufacturing industries where information processing equipment was not significant were primary and fabricated metals, transportation other than motor vehicles, food, paper, and petroleum.[16]

As Appendix Table A-1 shows, however, the regression results were somewhat less successful in the case of wholesale and retail trade. The equations generally performed as expected with the exception of the notorious interest and inflationary expectations variables *and* investment in information processing equipment.[17] While investment in information processing technology does have a significant impact in reducing the inventory-to-sales ratios for wholesale and retail durables, it does not have a significant effect for trade as a whole. This result seems perplexing since the trading sector's investment in information processing equipment soared from 9 percent of total investment in the late 1970s to close to 30 percent in the late 1980s, just as it did in durables manufacturing.

Three explanations appear plausible. First, in the early 1980s, much retail investment spending may have been focused on equipment unrelated to inventory management. Wal-Mart, for instance, was buying electric cash registers to replace the hand-crank variety at that time (Walton 1992, p. 124). In addition, retailers do not have the manufacturers' options for reducing work in process, or for cutting stocks by redesigning components or by requiring suppliers to provide entire subassemblies rather than individual parts. Finally, during the 1980s retailers were much taken with the idea of building distribution systems around large, central warehouses (Bechter and Stanley 1992; Walton 1992). This innovation replaced a "system" in which individual store managers would call salesmen and "then some day or other a truck from somewhere would come along and drop off the merchandise" (Walton 1992, p. 87). But, as Jay Forrester pointed out in his 1961 industrial dynamics text, adding a link to the distribution system increases the amount of inventory in the pipeline. In other words, adding a layer to the distribution system may have offset the gains permitted by better infor-

Investment in information processing equipment appears to have a negative relationship with the inventory-to-sales ratio for the economy as a whole and for most of the manufacturing sector.

[16] For fabricated metals and petroleum, however, the coefficient on investment in information processing equipment is negative and significant in the recent subperiod. Moreover, in the case of nonautomotive transportation, which is largely aerospace, finding an explanation for the coefficients on the investment and inflationary expectations variables is relatively easy; most aerospace work is done in response to specific, often government, orders received well before production starts. As Womack and his colleagues put it, spacecraft manufacture is one of the few remaining examples of craft production, wherein products are made one at a time to the customer's exact specification. This observation probably applies, to a lesser extent, to aircraft manufacture as well. In addition, in aerospace, the great bulk of inventory is held as work in process, the one type of manufacturing inventory that probably has a negative link with expected inflation. Because work in process cannot be stored, expectations of higher inflation cannot encourage a buildup of work in process in relation to sales. Such a buildup would simply represent a decline in efficiency. Indeed, because more rapid inflation would most likely lead to demands for higher wages, a pickup in the pace of inflation would probably encourage efforts to increase output per manhour. Since such efforts would lower the inventory-to-sales ratio, work in process probably has a negative relationship with expected inflation, and industries where work in process accounts for an unusually large share of total inventories will not behave like the average manufacturing industry, where inventories are fairly evenly divided between materials, work in process, and finished goods.

[17] Why does expected inflation, which generally has a positive link with the dependent variable in manufacturing, usually have a significant negative relationship with the inventory-to-sales ratio in trade? Retailers, it seems, often pursue a strategy of stocking up on bargains when they become available. A news item on Procter & Gamble Company is illustrative in this regard. Procter & Gamble recently announced a change in its pricing policies. It set a lower wholesale price on nearly half of its products and eliminated promotional allowances, because, in the company view, grocers have abused these discounts by stockpiling six or more months of goods when they are on special. Such practices have caused wild and undesirable fluctuations in Procter & Gamble's production schedule (Shapiro 1992). These bargain-oriented retail strategies (also documented by Berger 1992) imply a negative rather than a positive relationship between the change in prices and current inventories. Because retailers carry inventories of a vast but varying mix of products, they have some flexibility to bargain hunt. Manufacturers, by contrast, have considerably less flexibility since they produce a limited number of products that require specific inputs in fixed proportions. The consequences of having inadequate supplies of one particular item are far more dire for a manufacturer than for a retailer. At worst, a retailer may lose a sale or annoy a customer. In the case of a manufacturer, the entire production line may come to a halt.

mation processing equipment.[18] Indeed, according to manufacturers now reporting pressure to provide just-in-time service, it is only within the last year or two that retailers have reverted to requiring delivery direct to the store.

Evidence of Structural Change

Finally, because this article argues that U.S. businesses have changed their approach to inventory management to an important extent, it seems appropriate to check whether the shifts in the regression coefficients across subperiods represent a significant structural change.[19] One way to look for structural shifts is to run the regression equations for the entire period with (interactive) dummies on each of the independent variables during the recent period, that is, starting in the fourth quarter of 1982. As already explained, the break was determined by the appearance of the time series and the occurrence of key events, like the arrival of the Honda plant.[20] The regression coefficients on the dummies show the size and direction of the shifts while the t-statistics indicate whether the shift is statistically significant. Table 2 gives the coefficients and t-statistics for the recent-period dummies for manufacturing and trade, while Appendix Table A-2 provides the same information for the various sectors and individual industries.

As Tables 2 and A-2 show, in manufacturing and trade, manufacturing, and durables in manufacturing and wholesale and retail trade, the negative shift in the coefficient on investment in information processing equipment was statistically significant. Indeed, in almost two-thirds of the equations, this coefficient became (more) negative in the years after 1982, and in over one-third of the equations, the shift was significant.

For the economy as a whole, the relationship between investment in information processing equipment and the inventory-to-sales ratio was the only one to show a significant change. Nevertheless, in most equations, the coefficients on the lagged dependent variable and on unexpected changes in sales were slightly smaller in the more recent period. These declines suggest that the new approaches to inventory management may have led to somewhat more rapid adjustment of the inventory-to-sales ratio and that unexpected changes in sales may be having a less disruptive effect on desired inventories than previously.[21]

In this connection it is notable that the standard deviation of the detrended inventory-to-sales data is generally considerably smaller in the recent than in

Table 2
Testing for Structural Change and Stability using Dummy Variables, Manufacturing and Trade

F-statistic:	
Coefficients Significantly Different from Zero	391.29
Coefficients for Dummy Variables:[a]	
C	.38 (1.67)
Lagged Dependent	−.19 (−1.62)
Information Processing Investment/GDP (−4)	−.04 (−3.05)
Change in Interest Rate	.002 (.79)
Inflation	.003 (.62)
Unexpected Sales	.0009 (.41)
Percent Change in Sales	−.002 (−.71)

[a]Equation estimated using interactive dummy variables (1968:1 to 1982:3 = 0, 1982:4 to 1990:4 = 1).
Regressions results for other industries are shown in Appendix Table A-2.
F-statistic, critical value = 1.741 at the 5% level.
T-statistics in parentheses; critical value = 1.995 at the 5% level.

[18] Indeed, another quote from a Wal-Mart operations manager illustrates the volumes of goods and the delays involved in the warehouse setting: "Sometimes we would have five hundred trailers full of merchandise sitting around one of those warehouses. And it took time to deal with all that. We couldn't get it out. Then the next day we'd get sixty boxcar loads. We'd have to unload the doggoned boxcars, and here the merchandise they wanted in the stores would be sitting there sometimes a week or a week and a half" (Walton 1992, p. 122). This scene provides a vivid contrast to the new ideal of automatically replenished goods, delivered direct to the store and bypassing the warehouse entirely.

[19] Investment in information processing equipment is just a proxy for the introduction of these new approaches to inventory managment, some of which are not highly computer-dependent. Moreover, much of the investment in information processing equipment from the late 1960s to the present has clearly not been related to inventory control at all. Thus, part of the structural shift is the relatively recent availability of equipment devoted to inventory management.

[20] Minimizing the residual sum of the squares (using a dummy for recessions) suggests that the break comes in 1983:II.

[21] Partially offsetting this evidence of improved inventory control, the generally negative coefficients on the percent change

Table 3

Standard Deviations of the Detrended Inventory-to-Sales Ratios[a]

Industry	1968:1–1990:4	1968:1–1982:3	1982:4–1990:4
Manufacturing and Trade	.024	.026	.015
Manufacturing	.038	.042	.024
Durable Goods	.068	.074	.046
Nondurable Goods	.022	.024	.014
Durable Goods			
Primary Metals	.148	.165	.087
Fabricated Metal Products	.077	.082	.044
Industrial and Commercial Machinery	.076	.077	.058
Electrical Machinery	.059	.062	.043
Transportation Equipment	.134	.143	.111
Motor Vehicles and Parts	.099	.112	.056
Other Transportation Equipment	.165	.168	.153
Other Durable Goods	.051	.055	.033
Nondurable Goods			
Food and Kindred Products	.021	.023	.013
Nonfood	.029	.031	.020
Paper and Allied Products	.033	.036	.022
Chemicals and Allied Products	.050	.057	.032
Petroleum and Coal Products	.037	.037	.034
Rubber and Plastic Products	.060	.065	.040
Other Nondurable Goods	.032	.033	.023
Merchant Wholesalers	.024	.027	.018
Wholesale Durable Goods	.048	.049	.047
Wholesale Nondurable Goods	.021	.022	.014
Retail Trade	.028	.026	.027
Durable Goods	.086	.084	.079
Automotive Dealers	.118	.104	.123
Other Durable Goods	.065	.073	.038
Nondurable Goods	.014	.013	.012
Food Stores	.012	.012	.010
Other Nondurable Goods	.018	.018	.016

[a]Standard deviations of the residuals from regressing the inventory-to-sales ratio with time, estimated using AR2 to correct for second order serial correlation.

Source: Inventory-to-sales data from U.S. Bureau of Economic Analysis.

Figure 3

Manufacturing and Trade: Actual and Alternate Inventory-to-Sales Ratios

[a] Applying recent coefficients from regression results to the variables.
[b] Relationships held constant at levels derived for period 1968 to 1982.
[c] Recent coefficients used with ratio of information processing investment/GDP(-4) held constant at 1982:4 level.

the earlier period for all industries, except for retail trade, as shown in Table 3.[22] These results contrast with recent studies suggesting that the new management methods have increased the volatility of inventory investment (Bechter and Stanley 1992, for instance). Instead, these findings suggest that the new approach to inventory control may be helping producers and traders to keep their inventories closer to desired levels than was previously possible. If U.S. inventories are indeed becoming "better managed," perhaps they will become acyclical, as West (1991) has noted is the case in Japan. If so, restocking activity can no longer be expected to contribute much impetus to the early stages of a recovery.

Figure 3 illustrates the magnitude of the structural change implied by the statistical analysis presented in this section. The figure compares the actual behavior of the inventory-to-sales ratio for the period 1982:IV to 1990:IV with three estimates of what would have happened to that ratio under alternative circum-

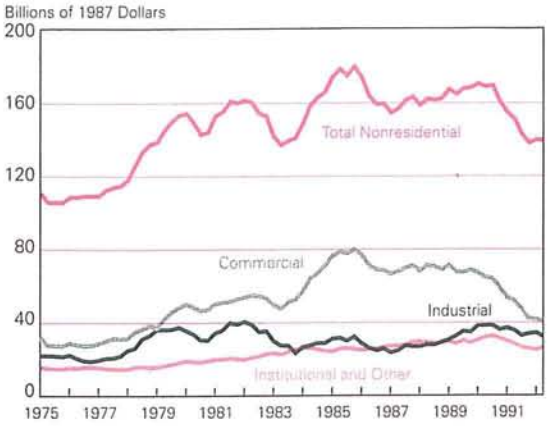
in sales became very slightly larger in many of the equations; however, this negative shift was significant only for non-automotive transportation and the auto dealers, and, thus, for total retail trade. In addition, the interest rate variable (and, in manufacturing, the inflationary expectations variable) was generally more likely to behave as expected in the earlier than in the later period.

[22] Within retail trade, auto dealer stocks appear to bear the blame. Auto dealers often face inventory constraints imposed by the car makers. For example, in order to obtain popular models, auto dealers may have to accept a proportionate number of unpopular models that the car makers want to unload.

stances.[23] The first estimate, derived by applying the coefficients from the regression results for the recent period to the independent variables, merely indicates that the estimates follow the actual ratios quite closely. A second estimate, using the coefficients from the early period, shows what would have happened to the inventory-to-sales ratio if the relationships between variables had remained unchanged from those derived for the period from 1968 to 1982. In sharp contrast to its actual behavior, by late 1990 the inventory-to-sales ratio would have been approaching its late 1982 peak, if the underlying relationships had not changed. The final estimate, which uses coefficients from the recent period but does not allow investment in information processing equipment as a share of GDP to rise from its 1982:IV level, suggests that this investment mattered. In other words, the new approaches to inventory management represented by this investment appear to be largely responsible for the observed decline in the inventory-to-sales ratio.

Figure 4

Expenditures on Private Nonresidential Structures



Source: U.S. Bureau of Economic Analysis.

Consequences for the Economy

The previous section presented statistical evidence suggesting that the relationship between the inventory-to-sales ratio and its determinants changed significantly in the 1980s, and that new approaches to inventory management, proxied by investment in information processing equipment, were largely responsible for the change. This section begins to explore the implications for the economy and the current recovery.

As already mentioned, reducing inventories both reflects and permits productivity improvements. Accordingly, the evidence of a structural change in the relationship between inventory and sales just presented is good news for the U.S. economy in the long run. It is even good news for this country's productivity performance and for corporate profits in the short run.

Nevertheless, the *transition* to lean inventory systems is currently exerting a noticeable drag on the U.S. economy. This drag takes two forms. First, a permanent reduction in the desired inventory-to-sales ratio requires absorbing goods from existing stocks, or, as some commentators put it, making a one-time cut in the length of the pipeline. In addition, lean inventory management permits considerable savings in space and in workers required to track and handle stocks. This second source of friction is probably the more important.

To start with the first issue, reducing the length of the pipeline requires satisfying part of current demand from existing stocks without replacing them. For a variety of reasons—but primarily, it seems, the introduction of new methods of inventory management—between late 1982 and late 1990, manufacturing and trade inventories declined from 1.68 to 1.43 months' sales. In manufacturing the decline was from 1.99 to 1.47 months' sales; in manufacturing durables, from 2.70 to 1.76. Those changes are equivalent to eliminating a week's worth of sales in manufacturing and trade combined or two weeks' worth of production in manufacturing. In manufactured durables, demand for a month's worth of output in effect evaporated. Spread over eight years, the evaporation of demand due to inventory reduction was probably not earthshaking. But such changes certainly must be contributing to the sensation that a frustrating "head wind" is slowing economic growth.

The second source of drag on the U.S. recovery is the significant savings in space and personnel permitted by the new approaches to inventory control.

[23] In these dynamic estimates, the lagged dependent variable was allowed to take the estimated value of the dependent variable in the previous period rather than its actual value.

This second source of friction was not addressed by the regressions developed for this article, but may, nevertheless, be the more consequential if the savings mentioned in the individual company anecdotes are at all representative.

In those anecdotes, to start with space, a company introducing a JIT or an MRPII inventory system frequently emptied one-third of the area formerly devoted to storing stocks. In addition, these companies found that they needed less space for the production line and the rework area. These savings may help to explain why industrial structures failed to participate fully in the real estate boom of the 1980s, as shown in Figure 4. In addition, David Shulman of Salomon Brothers has suggested that the next few years may witness a glut of warehouse space, in part because of the new approaches to inventory management (Shulman 1991).

Similarly, companies introducing new inventory management systems claim to reap considerable savings in personnel. Manufacturers need fewer people to move, track, and order materials and finished goods inventories. And, by definition, reducing work-in-process inventory involves increasing productivity. Retail firms have also found that they can reduce staffing for handling and managing inventory as well as clerks for manning the cash registers and marking and remarking merchandise. Accordingly, adoption of the new inventory management systems has undoubtedly contributed to the recent declines in manufacturing and retail employment. Firms' ability to "downsize" and "rightsize" may be partly attributable to their adopting new inventory management systems. Moreover, these changes are secular, not cyclical. As many observers have noted, "These jobs aren't coming back again."

If U.S. businesses have reduced employment because of new approaches to inventory management, their productivity should have increased as the inventory-to-sales ratio fell. And, indeed, Table 4 shows the results of a simple correlation between the inventory-to-sales ratio and output per manhour from 1968 to 1982 and 1982 to 1990. During the first period, the two series were largely uncorrelated. However, from 1982 to 1990, the correlation was very close to −1.0: the lower the inventory-to-sales ratio, the higher the output per manhour. While a thorough exploration of the links between lean inventories (or manufacturing) and productivity is beyond the scope of this paper, it seems highly likely that the recent spread of new approaches to inventory management has contributed to simultaneous increases in output per hour.

Table 4
Results of Correlation Procedure
Inventory-to-Sales Ratios and Output per Hour of All Persons

	1968:1–1982:3	1982:4–1990:4
Manufacturing	.346	−.974
Durable Goods	.375	−.960
Nondurable Goods	−.046	−.953

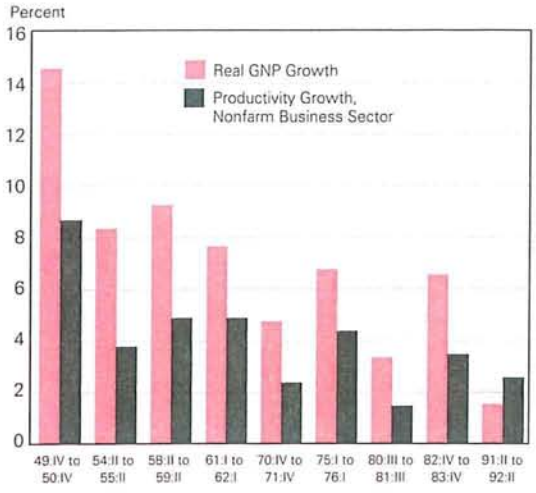
Source: U.S. Bureau of Economic Analysis; U.S. Bureau of Labor Statistics, *Employment and Earnings*.

Relevant, in this connection, are the results of a recent study on the impact of investment in high-tech equipment on manufacturing productivity (Steindel 1992). This study finds that investment in high-tech capital equipment "played a meaningful role in the recent acceleration in manufacturing productivity growth." But it also concluded that the increase in the total capital stock accounted for only 25 percent of the increase in labor productivity. Cyclical factors, measured by changes in capacity utilization, accounted for somewhat less than 25 percent of the improvement. Thus, "much of the acceleration in output per worker remains a mystery" (Steindel 1992, p. 47). Because some approaches to lean inventory management/lean manufacturing require changes in organization rather than capital spending (JIT inventory systems, for example), it seems possible that the introduction of these new approaches to manufacturing may account for part of the unexplained increase in productivity.

Welcome as increased productivity is over the long term, right now it may be slowing the current recovery by delaying the need to hire additional workers. Figure 5 shows the growth in output and the contribution of productivity improvements to that growth during the first year of recovery from each recession since the 1949–50 recovery (McNees 1992). The relationship between output and productivity increases looks radically different in this current slow recovery than in the previous upturns. Usually, productivity accounts for one-half to two-thirds of the growth in output. In the current recovery, however, productivity improvements account for more than the entire increase in real GNP. In other words, it seems highly likely that the new approach to inventory control is contributing not only to these productivity increases but also to the unusually slow pace of the recovery.

Figure 5

Growth in Real GNP and Productivity Growth, First Year of Expansions



Source: U.S. Bureau of Economic Analysis.

Is the Transition Complete?

Having just argued that lean inventory management will be a boon to U.S. productivity but that the transition, like so many transitions, may be painful, the question becomes, is the transition complete? The tentative answer, based on fragmentary international evidence and domestic anecdote, is no.

To start with the evidence from abroad, Womack and his colleagues have found that while the most efficient U.S. auto plants are as productive as the average Japanese plant, the average Big Three plant is still less effective than the average Japanese factory. The differences are particularly great in the distribution system, in assembler-supplier relations. For example, while the average U.S. auto plant has 2.9 days' inventory of eight sample parts on hand, the typical Japanese plant has 0.2 day's supply. Similarly, in the U.S. auto industry 15 percent of the parts are delivered just-in-time, whereas in Japan the proportion is 45 percent (Womack, Jones, and Roos 1990, p. 157). While the U.S. auto industry has moved towards more frequent deliveries (in 1983 over 70 percent of U.S. auto suppliers delivered more than a week's supply at once, while in 1990 that share had fallen to 20 percent), Womack and colleagues see this change not as a move to lean inventory management, but as the assemblers' attempt to shift the cost of carrying inventory to the suppliers (1990, p. 161). And indeed, as the author's conversations with auto suppliers corroborate, since most of these suppliers do not practice just-in-time manufacturing, they do not see many benefits for themselves in providing just-in-time deliveries to the assemblers. As the auto makers' recent efforts to renegotiate long-term contracts with suppliers suggests, assembler-supplier relations are not as mutually supportive in the United States as they are in Japan.[24] As for other manufacturing industries, West provides evidence that in Japan the average inventory-to-sales ratio in manufacturing from 1967:II to 1987:IV was 60 percent lower than it was in the United States in 1990.[25] In other words, the evidence from Japan suggests that U.S. manufacturers still have considerable scope for further reductions in their inventory-to-sales ratios.

Turning to domestic evidence, Appendix Table A-5 shows data on the inventory-to-sales ratio, by manufacturing industry, by size of firm, for 1977, 1982, and 1987, the latest date for which this information is available. The last row in each section gives the standard deviation (a measure of the variability) of the inventory-to-sales ratio across size of firm for each manufacturing industry. According to this measure, the variability in the inventory-to-sales ratio in the nondurables goods industries remained about the same from 1977 to 1987. However, in the durable goods industries, the standard deviations were considerably larger in 1987 than in 1977 or 1982. A plausible interpretation of this increased variability in the inventory-to-sales ratio across firm size is that the transition to lean inventory management was underway but not yet universal in durables manufacturing in 1987.[26]

[24] But, again, the current decline in Japanese domestic demand for autos is straining these assembler-supplier relationships.

[25] By contrast, U.S. retailers appear to be ahead of their colleagues in Europe. For example, electronic data interchange is not yet common in France, while in the United Kingdom, Marks & Spencer and Boots are investing in point-of-sale scanning equipment as the recession permits (Mercier and Uzeel 1992; Andersen 1992). Presumably, thus, Europe is also in the midst of its transition to lean inventory management.

[26] Again, anecdotal evidence suggests that the transition to lean inventory management/manufacturing takes time—especially in already existing plants. For more than a year, Ford's plant in Saarlouis, Germany has been experimenting with a lean production line running parallel to a traditional assembly line. Since the lean line uses 20 percent fewer workers to produce the same number of cars with half the defects, Ford plans to introduce lean methods throughout the plant; however, management expects the transition to take over four years (Aepel 1992).

More currently, anecdotal evidence suggests that the transition continues. U.S. manufacturers who switched to new inventory management systems some time ago indicate that they believe they can drive inventories down even further, that the optimum inventory-to-sales ratio has not yet been reached. They also report that their own company is ahead of its industry in its attention to inventory control. Press coverage of companies like Colt, F.A.O. Schwarz, and Home Depot indicates that many well-known firms are still making the transition to new inventory control programs. For instance, in mid 1992 Home Depot was just implementing an electronic data interchange purchasing program linking the company's inventory system with major vendors. Similarly, at Colt, which filed for Chapter 11 bankruptcy protection in March 1992, the new chief executive officer hired to turn the company around is planning to streamline the manufacturing process through just-in-time inventory control and other techniques that, he indicates, will require minimal capital investment (Bryant 1992).

Altogether, this scattered empirical and anecdotal evidence suggests that the move to inventory reduction is not yet complete. As a consequence, the transition to lean inventory management is likely to continue to slow the pace of U.S. economic growth for some time to come.

Conclusion

This article has presented evidence to suggest that the introduction of new approaches to inventory management represents a structural change for the U.S. economy. Moreover, while learning to live with lean inventories saves resources and will ultimately improve U.S. economic welfare unambiguously, the ongoing transition is slowing the recovery. In other words, the frequently recited list of structural issues overhanging the economy—the excessive debt burdens, the overbuilding in commercial real estate, and the demographic shifts—should be expanded to include the introduction of the new inventory systems. A focus on these new systems helps to explain several puzzling characteristics of the current recalcitant recovery: why, for instance, "these jobs really aren't coming back again;" why the anticipated rebuilding of unusually lean inventories did not reignite the economy; and why corporate profits and productivity improvements have been surprisingly good. Finally, these structural changes also suggest that policymakers probably have scope for more stimulative action than would have been appropriate in previous recoveries.

Appendix

Table A-1
Regression Results

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adj. R2
Total Manufacturing										
1968:1–1982:3	0.34	0.80	−0.001700	−0.003593	0.004162	−0.007412	−0.017	0.00		
	(8.88)	(34.39)	(−0.28)	(−2.95)	(3.95)	(−11.59)	(−12.47)	(0.00)	1.93	0.989
1982:4–1990:4	0.51	0.74	−0.046733	−0.001593	0.013510	−0.005793	−0.015	0.00		
	(3.51)	(12.56)	(−3.94)	(−0.49)	(2.81)	(−4.12)	(−4.61)	(0.00)	1.74	0.995
1968:1–1990:4	0.26	0.86	−0.012291	−0.002874	0.003630	−0.007383	−0.016	0.40		
	(6.42)	(37.84)	(−5.05)	(−2.51)	(3.17)	(−13.74)	(−10.57)	(3.70)	1.94	0.980
Durable Goods										
1968:1–1982:3	0.45	0.77	0.031370	−0.006257	0.004642	−0.007969	−0.023	0.10		
	(10.16)	(33.45)	(2.86)	(−3.49)	(2.86)	(−12.47)	(−14.31)	(0.67)	1.96	0.991
1982:4–1990:4	0.82	0.71	−0.091404	−0.001943	0.019152	−0.007348	−0.024	−0.20		
	(6.16)	(18.67)	(−6.80)	(−0.50)	(3.93)	(−5.60)	(−8.31)	(−0.99)	1.72	0.998
1968:1–1990:4	0.77	0.68	−0.045666	−0.004050	0.004280	−0.006739	−0.028	0.90		
	(7.04)	(16.07)	(−3.04)	(−3.05)	(1.51)	(−11.94)	(−16.09)	(19.80)	2.30	0.931

(Continued)

Table A-1 *continued* (2)
Regression Results

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adj. R2
Nondurable Goods										
1968:1–1982:3	0.13	0.91	−0.020929	−0.001896	0.003507	−0.008739	−0.008			
	(2.20)	(20.31)	(−3.78)	(−1.65)	(3.40)	(−8.90)	(−4.84)		2.25	0.930
1982:4–1990:4	0.29	0.78	−0.019755	−0.000571	0.008278	−0.002573	−0.007			
	(1.93)	(8.11)	(−2.18)	(−0.18)	(1.69)	(−1.55)	(−2.00)		1.89	0.976
1968:1–1990:4	0.18	0.86	−0.009223	−0.002178	0.001988	−0.006992	−0.009			
	(3.98)	(25.02)	(−4.39)	(−1.92)	(2.79)	(−8.04)	(−5.64)		1.85	0.977
Wholesale										
1968:1–1982:3	0.94	0.31	0.021473	−0.001181	−0.004580	−0.001602	−0.018	0.80		
	(5.39)	(2.37)	(0.90)	(−0.99)	(−1.81)	(−1.65)	(−7.42)	(8.37)	2.08	0.658
1982:4–1990:4	0.76	0.46	−0.013335	0.000053	0.001590	−0.000132	−0.018	0.30		
	(2.64)	(2.46)	(−1.87)	(0.01)	(0.21)	(−0.06)	(−3.55)	(1.00)	1.88	0.771
1968:1–1990:4	0.96	0.32	−0.010422	−0.001081	−0.002987	−0.001461	−0.018	0.80		
	(6.78)	(3.11)	(−1.62)	(−1.02)	(−1.48)	(−1.82)	(−8.91)	(10.38)	2.10	0.636
Wholesale Durable Goods										
1968:1–1982:3	0.19	0.92	0.014038	−0.003215	−0.002296	−0.008704	−0.018			
	(3.00)	(27.85)	(1.21)	(−1.55)	(−1.23)	(−7.97)	(−10.26)		1.88	0.975
1982:4–1990:4	0.81	0.64	−0.040051	0.000531	0.003727	−0.006267	−0.022			
	(4.69)	(9.54)	(−3.43)	(0.08)	(0.39)	(−2.18)	(−5.35)		2.24	0.956
1968:1–1990:4	0.24	0.89	−0.006456	−0.002858	0.001062	−0.008850	−0.017			
	(4.87)	(36.64)	(−2.64)	(−1.27)	(0.82)	(−7.97)	(−10.17)		1.73	0.962
Wholesale Nondurable Goods										
1968:1–1982:3	0.99	−0.09	−0.045842	−0.000605	−0.001986	0.000712	−0.012	0.90		
	(7.09)	(−0.62)	(−1.09)	(−0.47)	(−0.69)	(1.01)	(−5.52)	(13.66)	1.74	0.344
1982:4–1990:4	0.58	0.32	0.007623	0.000670	−0.004244	−0.000486	−0.011	0.60		
	(2.51)	(1.16)	(0.84)	(0.21)	(−0.59)	(−0.47)	(−3.61)	(2.37)	2.02	0.429
1968:1–1990:4	0.88	−0.01	−0.002313	−0.000415	−0.003203	0.000531	−0.012	0.90		
	(8.98)	(−0.12)	(−0.20)	(−0.39)	(−1.40)	(1.00)	(−7.16)	(18.57)	1.81	0.370
Retail										
1968:1–1982:3	0.38	0.75	0.014094	−0.002079	−0.004057	−0.005152	−0.014			
	(3.80)	(10.52)	(1.74)	(−1.35)	(−2.81)	(−4.32)	(−5.08)		2.29	0.845
1982:4–1990:4	0.76	0.51	0.006666	0.008902	−0.006671	−0.001548	−0.032			
	(3.30)	(2.74)	(0.43)	(1.70)	(−0.86)	(−0.60)	(−4.34)		1.61	0.887
1968:1–1990:4	0.51	0.66	0.009023	−0.000358	−0.003508	−0.004638	−0.018			
	(5.62)	(9.96)	(2.96)	(−0.23)	(−3.39)	(−4.07)	(−6.73)		1.96	0.896
Retail Durable Goods										
1968:1–1982:3	0.67	0.68	0.015944	−0.008464	−0.001405	−0.006549	−0.016			
	(4.15)	(8.02)	(0.63)	(−1.72)	(−0.29)	(−4.84)	(−4.47)		2.47	0.812
1982:4–1990:4	1.21	0.54	−0.045841	0.015477	−0.021928	−0.003331	−0.044			
	(6.07)	(5.32)	(−3.29)	(1.60)	(−1.58)	(−1.71)	(−7.95)		2.16	0.795
1968:1–1990:4	0.75	0.65	−0.013733	−0.003049	0.000619	−0.006254	−0.021			
	(5.75)	(9.51)	(−2.68)	(−0.69)	(0.19)	(−5.29)	(−7.07)		2.21	0.817
Retail Nondurable Goods										
1968:1–1982:3	0.32	0.74	0.000815	−0.002156	−0.003472	−0.002262	−0.014			
	(4.51)	(12.52)	(0.15)	(−2.32)	(−4.41)	(−1.55)	(−5.75)		1.51	0.859
1982:4–1990:4	0.20	0.84	−0.000205	0.003034	0.001794	−0.003647	−0.018			
	(1.64)	(6.83)	(−0.03)	(1.19)	(0.38)	(−1.48)	(−2.52)		2.06	0.934
1968:1–1990:4	0.26	0.79	0.005024	−0.001599	−0.003663	−0.003186	−0.014			
	(5.31)	(18.50)	(3.17)	(−1.86)	(−5.81)	(−2.62)	(−6.34)		1.59	0.957

Table A-1 *continued* (3)

Regression Results

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adj. R2
Manufacturing Durable Goods										
Primary Metals										
1968:1–1982:3	0.09	0.97	−0.048128	−0.011311	0.006840	−0.010175	−0.026	−0.10		
	(1.92)	(36.02)	(−1.57)	(−2.29)	(1.87)	(−11.49)	(−14.36)	(−0.68)	1.99	0.986
1982:4–1990:4	−0.05	0.88	−0.011734	0.011522	0.076152	−0.010194	−0.017	−0.20		
	(−0.48)	(31.18)	(−0.88)	(1.25)	(6.77)	(−6.61)	(−6.62)	(−1.03)	1.89	0.995
1968:1–1990:4	0.20	0.89	−0.005912	−0.006773	0.007561	−0.009155	−0.027	0.30		
	(3.79)	(41.14)	(−0.86)	(−1.53)	(2.25)	(−13.46)	(−13.60)	(2.73)	2.11	0.967
Fabricated Metals										
1968:1–1982:3	0.46	0.75	0.027292	0.000417	0.005264	−0.006845	−0.028	0.60		
	(3.14)	(8.86)	(0.65)	(0.12)	(0.88)	(−5.66)	(−7.68)	(4.41)	2.09	0.884
1982:4–1990:4	0.94	0.66	−0.058109	0.001101	−0.017131	−0.005644	−0.025	0.00		
	(2.62)	(5.53)	(−2.56)	(0.16)	(−1.27)	(−3.48)	(−4.85)	(0.00)	1.92	0.976
1968:1–1990:4	0.35	0.83	−0.008597	−0.000782	0.004754	−0.007212	−0.025	0.50		
	(3.80)	(17.65)	(−1.29)	(−0.26)	(1.29)	(−8.64)	(−9.49)	(4.60)	2.15	0.912
Industrial & Commercial Machinery										
1968:1–1982:3	1.60	0.43	0.016601	−0.002164	0.010134	−0.005125	−0.043	0.90		
	(8.73)	(7.34)	(0.31)	(−1.41)	(2.96)	(−4.77)	(−13.37)	(24.48)	2.38	0.934
1982:4–1990:4	0.51	0.83	−0.104470	−0.003654	0.035510	−0.008045	−0.022	0.40		
	(2.38)	(19.08)	(−3.10)	(−0.58)	(2.88)	(−6.02)	(−6.69)	(2.08)	1.75	0.995
1968:1–1990:4	1.00	0.69	−0.129000	−0.002279	0.013830	−0.008085	−0.030	0.90		
	(5.97)	(15.25)	(−4.82)	(−1.24)	(3.51)	(−9.07)	(−11.52)	(22.31)	2.40	0.932
Electronic Machinery										
1968:1–1982:3	1.13	0.49	0.046047	−0.004036	0.006673	−0.004219	−0.027	0.70		
	(5.90)	(5.61)	(1.46)	(−1.94)	(1.52)	(−3.49)	(−9.62)	(5.78)	2.05	0.870
1982:4–1990:4	0.93	0.69	−0.088875	−0.005720	0.018048	−0.005978	−0.026	0.60		
	(2.04)	(4.73)	(−2.83)	(−0.86)	(1.11)	(−2.93)	(−4.16)	(3.90)	2.24	0.888
1968:1–1990:4	1.34	0.47	−0.055348	−0.004059	0.003711	−0.004021	−0.028	0.90		
	(6.87)	(6.21)	(−2.55)	(−2.33)	(0.92)	(−4.21)	(−12.41)	(18.07)	2.10	0.826
Motor Vehicles & Parts										
1968:1–1982:3	0.26	0.80	−0.046658	−0.007147	0.000125	−0.003901	−0.011			
	(3.94)	(11.71)	(−2.07)	(−1.80)	(0.03)	(−8.41)	(−9.61)		2.12	0.881
1982:4–1990:4	0.24	0.77	−0.028008	0.000101	0.006864	−0.002448	−0.009			
	(1.90)	(6.86)	(−2.54)	(0.01)	(0.65)	(−4.46)	(−6.09)		1.72	0.877
1968:1–1990:4	0.29	0.77	−0.029661	−0.006711	−0.001237	−0.003454	−0.011			
	(5.29)	(13.98)	(−4.43)	(−2.02)	(−0.50)	(−9.52)	(−12.04)		2.15	0.950
Other Transportation										
1968:1–1982:3	0.64	0.81	0.104010	0.003648	−0.006163	−0.014497	−0.038			
	(2.96)	(14.46)	(2.48)	(0.47)	(−0.92)	(−6.94)	(−6.39)		1.71	0.929
1982:4–1990:4	0.37	0.91	−0.024926	−0.020543	0.042378	−0.015601	−0.074			
	(0.96)	(10.98)	(−0.93)	(−0.98)	(1.29)	(−4.56)	(−6.09)		1.76	0.919
1968:1–1990:4	0.20	0.94	0.023994	0.007954	0.004672	−0.016980	−0.034			
	(1.34)	(25.91)	(2.24)	(1.00)	(1.03)	(−9.11)	(−6.93)		1.68	0.943
Other Durable Goods										
1968:1–1982:3	0.46	0.75	0.017132	−0.003573	0.004159	−0.007245	−0.019	0.50		
	(3.77)	(10.47)	(0.78)	(−1.71)	(1.36)	(−7.60)	(−6.58)	(3.43)	1.80	0.930
1982:4–1990:4	0.71	0.70	−0.053795	−0.000467	0.004005	−0.004878	−0.021	0.40		
	(2.47)	(6.49)	(−2.55)	(−0.08)	(0.37)	(−3.43)	−4.03)	(1.70)	1.83	0.948
1968:1–1990:4	0.34	0.83	−0.014073	−0.002953	0.004234	−0.007389	−0.018	0.50		
	(4.47)	(20.24)	(−3.11)	(−1.55)	(1.88)	(−10.49)	(−7.75)	(4.63)	1.91	0.934

[a]Polynomial Distributed Lag (first degree polynomial, 3 quarters including current quarter, far endpoint constraint).
[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.
Coefficients shown are the sum of the estimated lagged coefficients.
T-statistics in parentheses; critical value = 1.993 at the 5% level.

Table A-1 *continued* (4)
Regression Results

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adj. R2
Manufacturing Nondurable Goods										
Food and Kindred Products										
1968:1–1982:3	0.24	0.78	−0.007914	−0.000208	0.000222	−0.002233	−0.006			
	(2.23)	(7.74)	(−0.72)	(−0.10)	(0.13)	(−1.78)	(−2.01)		1.95	0.523
1982:4–1990:4	0.09	0.91	−0.004091	0.000561	0.000936	−0.003285	−0.012			
	(0.74)	(8.78)	(−0.46)	(0.20)	(0.21)	(−1.35)	(−2.98)		2.36	0.966
1968:1–1990:4	0.20	0.82	−0.012965	−0.000116	0.000810	−0.002366	−0.007			
	(2.72)	(12.01)	(−2.81)	(−0.07)	(0.87)	(−2.35)	(−2.92)		2.02	0.949
Paper & Allied Products										
1968:1–1982:3	0.21	0.83	−0.001799	−0.003252	0.003141	−0.006836	−0.015			
	(4.91)	(22.19)	(−0.17)	(−1.78)	(1.81)	(−6.37)	(−7.95)		1.73	0.964
1982:4–1990:4	0.37	0.69	−0.000442	−0.001445	0.007898	−0.003830	−0.014			
	(2.94)	(7.24)	(−0.11)	(−0.32)	(1.30)	(−2.18)	(−4.12)		2.37	0.818
1968:1–1990:4	0.23	0.81	0.002218	−0.002909	0.003004	−0.006233	−0.015			
	(6.50)	(26.61)	(1.15)	(−1.83)	(2.84)	(−7.08)	(−10.15)		1.84	0.955
Chemicals and Allied Products										
1968:1–1982:3	0.18	0.93	−0.044018	0.000439	0.001128	−0.009769	−0.022	0.20		
	(2.63)	(24.75)	(−3.36)	(0.19)	(0.47)	(−9.59)	(−9.68)	(1.37)	1.92	0.951
1982:4–1990:4	0.69	0.64	−0.029417	0.003590	−0.004240	−0.003515	−0.023	0.20		
	(2.62)	(5.04)	(−2.67)	(0.57)	(−0.37)	(−1.68)	(−5.04)	(0.85)	1.97	0.918
1968:1–1990:4	0.32	0.85	−0.016584	0.000540	−0.002583	−0.007791	−0.023	0.40		
	(3.57)	(17.72)	(−3.28)	(0.25)	(−1.32)	(−8.54)	(−10.65)	(3.53)	1.93	0.927
Petroleum and Coal Products										
1968:1–1982:3	0.07	0.89	−0.008596	0.000264	0.004090	−0.005736	−0.007			
	(1.50)	(13.45)	(−0.65)	(0.12)	(2.39)	(−6.07)	(−3.96)		1.74	0.882
1982:4–1990:4	0.59	0.40	−0.062622	−0.011182	0.026458	0.000668	−0.001			
	(3.19)	(2.56)	(−3.55)	(−1.49)	(2.09)	(0.42)	(−0.19)		1.89	0.878
1968:1–1990:4	0.08	0.89	−0.001338	−0.002365	0.002746	−0.003206	−0.006			
	(2.08)	(19.13)	(−0.45)	(−0.90)	(1.96)	(−3.45)	(−3.03)		1.79	0.840
Rubber and Plastic Products										
1968:1–1982:3	0.24	0.85	−0.017411	−0.000377	0.004779	−0.006151	−0.012			
	(3.75)	(16.72)	(−1.08)	(−0.14)	(1.42)	(−7.67)	(−6.30)		2.05	0.960
1982:4–1990:4	0.15	0.87	−0.011337	0.010446	0.015695	−0.006117	−0.013			
	(1.18)	(13.07)	(−1.05)	(1.96)	(2.04)	(−5.97)	(−4.67)		2.26	0.963
1968:1–1990:4	0.25	0.84	−0.017175	0.000710	0.005704	−0.006071	−0.012			
	(5.81)	(25.75)	(−5.13)	(0.31)	(2.56)	(−10.20)	(−8.91)		2.06	0.980
Other Nondurable Goods										
1968:1–1982:3	1.30	0.31	−0.086354	−0.004426	0.008524	−0.001983	−0.019	0.80		
	(6.75)	(3.04)	(−3.01)	(−3.16)	(2.66)	(−1.58)	(−6.61)	(7.86)	1.80	0.770
1982:4–1990:4	0.53	0.75	−0.038241	0.003349	−0.004848	−0.004679	−0.017	0.30		
	(2.15)	(6.10)	(−2.14)	(0.61)	(−0.49)	(−2.19)	(−3.52)	(1.31)	1.99	0.947
1968:1–1990:4	0.81	0.58	−0.055932	−0.004105	0.004832	−0.004192	−0.016	0.50		
	(4.70)	(6.30)	(−4.82)	(−2.69)	(2.47)	(−3.60)	(−7.01)	(3.86)	1.90	0.955

[a]Polynomial Distributed Lag (first degree polynomial, 3 quarters including current quarter, far endpoint constraint).
[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.
Coefficients shown are the sum of the estimated lagged coefficients.
T-statistics in parentheses; critical value = 1.993 at the 5% level.

Table A-1 *continued* (5)

Regression Results

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adj. R2
Retail Durable Goods										
Auto Dealers										
1968:1–1982:3	0.70	0.55	0.013873	−0.006499	0.008659	−0.004786	−0.01			
	(4.41)	(5.09)	(0.37)	(−0.92)	(1.15)	(−3.80)	(−2.70)		2.37	0.728
1982:4–1990:4	0.92	0.59	−0.004200	0.024676	−0.034246	−0.004571	−0.04			
	(5.04)	(4.61)	(−0.13)	(1.54)	(−1.44)	(−2.10)	(−6.90)		2.19	0.874
1968:1–1990:4	0.67	0.59	0.011095	0.003763	0.003499	−0.004768	−0.02			
	(5.71)	(7.48)	(1.21)	(0.55)	(0.72)	(−4.06)	(−5.54)		2.19	0.734
Retail Other Durable Goods										
1968:1–1982:3	0.52	0.84	−0.002642	−0.007868	−0.009278	−0.011009	−0.03			
	(3.76)	(16.56)	(−0.17)	(−2.40)	(−3.25)	(−7.09)	(−8.29)		1.77	0.902
1982:4–1990:4	0.90	0.69	−0.065266	−0.004959	0.010898	−0.008657	−0.02			
	(3.33)	(7.96)	(−3.31)	(−0.68)	(0.98)	(−2.75)	(−2.90)		2.19	0.959
1968:1–1990:4	0.478	0.86	−0.028039	−0.008111	−0.004978	−0.011428	−0.02			
	(4.25)	(21.39)	(−4.60)	(−2.80)	(−2.66)	(−8.55)	(−8.83)		1.81	0.970
Retail Nondurable Goods										
Food Stores										
1968:1–1982:3	0.18	0.71	0.012177	−0.000799	0.000108	−0.002361	−0.01			
	(4.13)	(10.16)	(2.33)	(−1.05)	(0.18)	(−3.24)	(−5.98)		1.96	0.908
1982:4–1990:4	0.23	0.61	0.022623	−0.003423	0.001422	−0.000436	−0.00			
	(1.79)	(2.97)	(2.10)	(−1.43)	(0.36)	(−0.31)	(−0.27)		2.39	0.943
1968:1–1990:4	0.20	0.68	0.017748	−0.001252	−0.000457	−0.001767	−0.01			
	(4.73)	(9.94)	(4.82)	(−1.63)	(−1.13)	(−2.66)	(−5.54)		2.10	0.981
Retail Other Nondurable Goods										
1968:1–1982:3	0.35	0.78	−0.006907	−0.003193	−0.004504	−0.002065	−0.01	0.30		
	(2.38)	(7.71)	(−0.55)	(−2.33)	(−2.83)	(−1.19)	(−3.45)	(1.60)	2.07	0.824
1982:4–1990:4	0.88	0.33	0.003624	−0.000758	0.013149	−0.002740	−0.02	0.60		
	(2.88)	(1.52)	(0.38)	(−0.23)	(1.88)	(−1.14)	(−2.87)	(3.79)	2.36	0.617
1968:1–1990:4	0.32	0.79	0.000053	−0.002424	−0.005001	−0.003448	−0.01	0.30		
	(3.45)	(12.17)	(0.02)	(−1.97)	(−3.87)	(−2.51)	(−4.27)	(2.29)	2.07	0.837

Memo:

Inventory Regressions Variable List

Variable	Units	Source
Dependent Variable:		
Inventory-to-Sales Ratio	Ratio, Based on 1982 Dollars	U.S. Bureau of Economic Analysis
Independent Variables:		
Lagged Dependent:		
Inventory/Sales (−1)	Ratio, Based on 1982 Dollars	U.S. Bureau of Economic Analysis
Information Processing Investment (−4)/ Gross Domestic Product	Ratio, Based on 1982 Dollars	U.S. Bureau of Economic Analysis
Change in the Interest Rate[a]	Percentage Points	Board of Governors of the Federal Reserve System
Change in the Inflation Rate[b]	Percent	U.S. Bureau of Labor Statistics
Unexpected Sales[c]	Percentage Points	Sales data from U.S. Bureau of Economic Analysis
Percent Change in Sales[d]	Percent	Sales data from U.S. Bureau of Economic Analysis

[a]Difference between current quarter and previous quarter, 3-month CD Rate.
[b]Percent change in CPI (less foods and fuels) from a year ago (CORE inflation).
[c]Difference in the percent change from that of the previous quarter.
[d]Percent change in sales from previous quarter.

Table A-2

Testing for Structural Change and Stability using Dummy Variables

	F-statistic: Coefficients Significantly Different from Zero	Coefficients for Dummy Variable:[a]						
		C	Lagged Dependent	Information Process. Invest./ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales
Manufacturing	1166.10	0.186	−0.06	−0.04576	0.00205	0.00917	0.00165	0.00060
		(1.24)	(−0.97)	(−3.45)	(0.60)	(1.88)	(1.08)	(0.33)
Durable Goods	1535.00	0.388	−0.07	−0.12348	0.00440	0.01322	0.00067	−0.00107
		(2.20)	(−1.30)	(−6.23)	(0.91)	(1.98)	(0.44)	(−0.55)
Primary Metals	499.30	−0.115	−0.09	0.03336	0.02145	0.06654	−0.00014	0.00535
		(−0.63)	(−1.83)	(0.92)	(1.55)	(3.64)	(−0.07)	(2.38)
Fabricated Metal Products	204.23	0.737	−0.24	−0.05586	−0.00086	−0.01963	0.00326	−0.00002
		(1.54)	(−1.44)	(−1.52)	(−0.08)	(−1.03)	(1.21)	(−0.01)
Industrial & Commercial Machinery	1635.80	0.120	−0.01	−0.11824	−0.00014	0.03177	0.00641	−0.00017
		(0.42)	(−0.18)	(−2.35)	(−0.01)	(2.26)	(2.16)	(−0.06)
Electrical Machinery	203.89	−0.605	0.28	−0.04034	0.00111	0.00823	−0.00357	0.00411
		(−1.75)	(2.54)	(−1.62)	(0.12)	(0.57)	(−1.30)	(1.37)
Motor Vehicles & Parts	136.32	−0.011	−0.03	0.01750	0.00775	0.00616	0.00150	0.00057
		(−0.06)	(−0.18)	(0.68)	(0.70)	(0.39)	(1.65)	(0.48)
Other Transportation Equipment	151.89	−0.268	0.10	−0.12860	−0.02509	0.04806	−0.00100	−0.01869
		(−0.60)	(0.95)	(−2.59)	(−1.09)	(1.38)	(−0.25)	(−2.71)
Other Durable Goods	269.94	0.197	−0.06	−0.04354	0.00241	0.00205	0.00264	0.00123
		(0.87)	(−0.60)	(−2.07)	(0.33)	(0.20)	(1.18)	(0.51)
Nondurable Goods	338.10	0.164	−0.13	0.00106	0.00134	0.00469	0.00617	0.00036
		(1.02)	(−1.19)	(0.10)	(0.39)	(0.93)	(3.18)	(0.18)
Food & Kindred Products	123.42	−0.146	0.13	0.00376	0.00086	0.00062	−0.00103	−0.00280
		(−0.64)	(0.66)	(0.22)	(0.17)	(0.08)	(−0.25)	(−0.81)
Paper and Allied Products	144.05	0.158	−0.13	0.00133	0.00173	0.00487	0.00299	0.00073
		(1.01)	(−1.13)	(0.12)	(0.31)	(0.66)	(1.30)	(0.33)
Chemicals and Allied Products	243.20	0.462	−0.26	0.01593	0.00498	−0.00414	0.00635	−0.00038
		(1.98)	(−2.30)	(1.11)	(0.70)	(−0.40)	(2.57)	(−0.17)
Petroleum and Coal Products	55.60	0.514	−0.50	−0.05434	−0.01165	0.02308	0.00630	0.00348
		(3.09)	(−3.27)	(−2.60)	(−1.68)	(2.08)	(3.64)	(1.45)
Rubber and Plastic Products	335.88	−0.081	0.01	0.00522	0.01117	0.01064	0.00010	−0.00057
		(−0.45)	(0.14)	(0.25)	(1.45)	(0.98)	(0.06)	(−0.27)
Other Nondurable Goods	485.29	0.012	0.02	0.01199	0.00900	−0.00896	0.00293	−0.00105
		(0.06)	(0.15)	(0.66)	(1.58)	(−1.03)	(1.00)	(−0.45)
Merchant Wholesalers	46.77	0.448	−0.33	−0.01110	0.00007	0.00380	0.00439	−0.00273
		(2.28)	(−2.49)	(−1.17)	(0.02)	(0.58)	(1.45)	(−1.26)
Durable Goods	228.05	0.587	−0.26	−0.05276	0.00304	0.00672	0.00225	−0.00191
		(3.60)	(−3.81)	(−3.29)	(0.45)	(0.73)	(0.77)	(−0.91)
Nondurable Goods	32.73	0.076	−0.11	0.01020	−0.00257	0.00016	0.00070	−0.00149
		(0.40)	(−0.51)	(0.91)	(−0.58)	(0.02)	(0.37)	(−0.74)
Retail	66.95	0.393	−0.25	−0.00556	0.01118	−0.00237	0.00357	−0.00808
		(1.63)	(−1.32)	(−0.34)	(2.17)	(−0.32)	(1.32)	(−2.22)
Durable Goods	39.19	0.565	−0.16	−0.06000	0.02456	−0.02115	0.00338	−0.01365
		(1.89)	(−1.01)	(−2.06)	(1.84)	(−1.13)	(1.20)	(−3.47)
Automotive Dealers	27.13	0.242	0.02	−0.01410	0.03241	−0.04402	0.00038	−0.01560
		(0.93)	(0.12)	(−0.28)	(1.64)	(−1.54)	(0.13)	(−3.97)
Other Durable Goods	244.06	0.367	−0.14	−0.06188	0.00267	0.02056	0.00229	0.00361
		(1.06)	(−1.26)	(−2.24)	(0.29)	(1.52)	(0.57)	(0.83)

Table A-2 *continued*

Testing for Structural Change and Stability using Dummy Variables

	F-statistic: Coefficients Significantly Different from Zero	Coefficients for Dummy Variable:[a] C	Lagged Dependent	Information Process. Invest./ GDP (−4)	Change in Interest Rate	Inflation	Unexpected Sales	Percent Change in Sales
Nondurable Goods	158.05	−0.120	0.09	−0.00043	0.00511	0.00569	−0.00158	−0.00090
		(−0.84)	(0.67)	(−0.05)	(1.84)	(1.16)	(−0.55)	(−0.24)
Food Stores	379.38	0.053	−0.11	0.01063	−0.00292	0.00169	0.00187	0.00411
		(0.43)	(−0.57)	(0.96)	(−1.30)	(0.48)	(1.26)	(2.03)
Other Nondurable Goods	70.47	0.004	−0.03	−0.00280	0.00812	0.01017	−0.00302	−0.00007
		(0.02)	(−0.22)	(−0.27)	(2.00)	(1.56)	(−0.89)	(−0.02)

[a]Equation estimated using interactive dummy variables (1968:1 to 1982:3 = 0, 1982:4 to 1990:4 = 1).
F-statistic, critical value = 1.741 at the 5% level.
T-statistics in parentheses; critical value = 1.995 at the 5% level.

Table A-3

Regression Results, Forward Looking

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Expected Sales[a]	Unexpected Sales	Rho[b]	Durbin Watson	Adj. R2
Manufacturing and Trade										
1968:1–1982:3	0.76	0.50	0.006	−0.000868	0.003299	0.004574	0.001349	0.70		
	(8.96)	(8.77)	(0.73)	(−1.32)	(3.08)	(12.95)	(1.76)	(6.58)	2.54	0.939
1982:4–1990:4	0.62	0.61	−0.020	−0.000729	0.007622	0.002543	−0.000985	0.50		
	(1.94)	(3.35)	(−1.66)	(−0.26)	(1.45)	(2.64)	(−0.29)	(1.77)	1.83	0.908
1968:1–1990:4	0.75	0.52	−0.016	−0.001360	0.004768	0.003965	0.000606	0.80		
	(7.96)	(8.80)	(−3.42)	(−2.08)	(4.01)	(12.07)	(0.78)	(8.66)	2.23	0.899
Total Manufacturing										
1968:1–1982:3	0.49	0.70	−0.004	−0.001045	0.006672	0.009897	−0.000979	0.20		
	(13.05)	(30.74)	(−0.69)	(−1.07)	(7.88)	(15.74)	(−1.52)	(1.36)	1.99	0.990
1982:4–1990:4	0.54	0.70	−0.040	−0.003287	0.016730	0.006641	−0.000521	0.00		
	(3.32)	(9.67)	(−3.44)	(−0.99)	(3.51)	(4.20)	(−0.23)	(0.00)	1.66	0.994
1968:1–1990:4	0.39	0.77	−0.015	−0.001553	0.006738	0.008422	−0.002039	0.40		
	(9.82)	(35.06)	(−6.65)	(−1.45)	(7.19)	(12.53)	(−2.92)	(3.31)	1.85	0.984
Durable Goods										
1968:1–1982:3	0.87	0.55	−0.118	0.000232	0.011350	0.026996	0.000123	0.80		
	(9.55)	(10.93)	(−3.91)	(0.18)	(4.83)	(17.42)	(0.15)	(9.36)	2.25	0.965
1982:4–1990:4	0.50	0.68	−0.064	−0.010979	0.030321	0.015065	−0.003311	0.00		
	(2.27)	(7.81)	(−2.77)	(−1.88)	(3.73)	(3.65)	(−1.15)	(0.00)	1.35	0.993
1968:1–1990:4	0.82	0.57	−0.100	−0.002188	0.012546	0.023157	−0.000952	0.70		
	(10.27)	(15.40)	(−11.73)	(−1.44)	(5.57)	(14.61)	(−1.16)	(8.53)	2.02	0.960

[a]The Expected Sales variable was generated in three steps: 1) Estimated the equation ln Sales = ln b * Time + ln c to create a sales trend based on average percentage growth from one quarter to the next ($ST = \widehat{\ln b} * Time + \widehat{\ln c}$). 2) Corrected for last quarter's deviation of actual sales from the trend by estimating Sales = ST + b(Sales(−1) − ST(−1)). The new corrected sales trend was calculated using the equation S = ST + b(Sales(−1) − ST(−1)). 3) Subtracted actual sales from the corrected sales trend to produce the expected sales variable used in the forward looking equations. (See Bechter and Pollock 1981.)

[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.

T-statistics in parentheses; critical value = 1.993 at the 5% level.

Table A-3 *continued* (2)

Regression Results, Forward Looking

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Expected Sales[a]	Unexpected Sales	Rho[b]	Durbin Watson	Adj. R2
Nondurable Goods										
1968:1–1982:3	0.24	0.81	−0.020	−0.001463	0.004412	0.009304	−0.005544			
	(4.31)	(19.33)	(−3.87)	(−1.38)	(5.34)	(6.18)	(−5.35)		2.16	0.941
1982:4–1990:4	0.40	0.69	−0.024	−0.000025	0.009359	0.008884	0.001049			
	(2.60)	(6.69)	(−2.67)	(−0.01)	(2.18)	(2.75)	(0.48)		1.97	0.978
1968:1–1990:4	0.28	0.78	−0.012	−0.001669	0.003510	0.009458	−0.003725			
	(6.27)	(23.04)	(−6.13)	(−1.56)	(6.19)	(7.02)	(−3.94)		1.88	0.980
Manufacturing Durable Goods										
Primary Metals										
1968:1–1982:3	0.18	0.86	0.047	−0.004547	0.014066	0.185820	−0.001270	0.50		
	(2.06)	(17.84)	(0.87)	(−1.11)	(2.44)	(14.16)	(−1.23)	(3.87)	2.28	0.961
1982:4–1990:4	−0.13	0.86	0.007	0.011022	0.091662	0.161200	−0.005019	−0.20		
	(−1.19)	(27.25)	(0.51)	(1.11)	(8.16)	(5.93)	(−2.78)	(−1.02)	1.79	0.994
1968:1–1990:4	0.22	0.84	0.004	−0.003498	0.021613	0.185620	−0.001348	0.60		
	(2.74)	(26.16)	(0.39)	(−0.95)	(4.96)	(15.62)	(−1.56)	(6.22)	2.33	0.942
Fabricated Metals										
1968:1–1982:3	0.57	0.68	0.003	0.001967	0.015362	0.186570	−0.000147	0.60		
	(3.54)	(7.40)	(0.06)	(0.52)	(2.67)	(6.94)	(−0.08)	(4.27)	2.04	0.872
1982:4–1990:4	0.89	0.63	−0.036	−0.002723	−0.008899	0.172270	0.001027	−0.10		
	(3.19)	(6.36)	(−2.19)	(−0.47)	(−0.89)	(6.18)	(0.47)	(−0.44)	1.90	0.984
1968:1–1990:4	0.49	0.73	−0.008	−0.000235	0.013336	0.171450	−0.000606	0.50		
	(5.09)	(15.05)	(−1.14)	(−0.08)	(3.83)	(9.11)	(−0.50)	(4.57)	2.11	0.910
Industrial & Commercial Machinery										
1968:1–1982:3	0.88	0.67	−0.039	−0.000919	0.013528	0.181830	−0.000926	0.70		
	(4.90)	(9.82)	(−1.12)	(−0.44)	(3.58)	(9.19)	(−0.48)	(6.58)	2.37	0.930
1982:4–1990:4	0.19	0.88	−0.036	−0.007479	0.026713	0.060422	−0.004146	0.60		
	(0.65)	(13.48)	(−0.82)	(−0.98)	(1.44)	(4.15)	(−1.80)	(3.07)	1.72	0.982
1968:1–1990:4	0.44	0.83	−0.066	−0.004192	0.016832	0.083457	−0.006386	0.60		
	(4.33)	(25.65)	(−4.74)	(−1.58)	(4.64)	(6.48)	(−4.28)	(6.08)	2.06	0.979
Electronic Machinery										
1968:1–1982:3	1.20	0.44	0.028	0.001455	0.013738	0.229380	0.002766	0.70		
	(5.99)	(4.67)	(0.88)	(0.65)	(3.18)	(9.88)	(1.68)	(5.58)	1.92	0.871
1982:4–1990:4	0.70	0.76	−0.078	−0.006367	0.024408	0.141570	−0.000824	0.70		
	(1.54)	(5.18)	(−2.25)	(−0.99)	(1.51)	(4.55)	(−0.30)	(5.22)	2.04	0.843
1968:1–1990:4	1.17	0.50	−0.045	−0.001052	0.011638	0.188050	0.001572	0.90		
	(5.17)	(5.66)	(−1.72)	(−0.54)	(2.67)	(10.95)	(1.13)	(13.22)	2.05	0.795
Motor Vehicles & Parts										
1968:1–1982:3	0.46	0.59	−0.094	0.000136	0.008213	0.080706	−0.000856			
	(5.99)	(7.77)	(−3.97)	(0.03)	(2.00)	(8.58)	(−1.29)		1.93	0.864
1982:4–1990:4	0.30	0.62	−0.016	−0.008860	0.006711	0.045395	−0.000313			
	(2.32)	(5.21)	(−1.62)	(−1.31)	(0.65)	(6.19)	(−0.42)		2.01	0.880
1968:1–1990:4	0.40	0.62	−0.041	−0.002812	0.004725	0.064700	−0.001066			
	(5.78)	(9.03)	(−4.93)	(−0.68)	(1.68)	(8.79)	(−1.86)		2.03	0.929
Other Transportation										
1968:1–1982:3	0.30	0.91	0.021	0.005855	0.002447	0.334680	−0.008161			
	(1.37)	(16.31)	(0.47)	(0.68)	(0.34)	(4.64)	(−2.33)		1.69	0.911
1982:4–1990:4	0.42	0.86	−0.020	−0.011475	0.059067	0.553240	0.004287			
	(1.10)	(10.44)	(−0.72)	(−0.56)	(1.82)	(6.01)	(0.81)		1.42	0.917
1968:1–1990:4	0.24	0.93	0.010	0.006079	0.003576	0.388850	−0.005982			
	(1.63)	(26.37)	(0.98)	(0.78)	(0.80)	(7.38)	(−2.20)		1.57	0.945

Table A-3 *continued* (3)

Regression Results, Forward Looking

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Expected Sales[a]	Unexpected Sales	Rho[b]	Durbin Watson	Adj. R2
Other Durable Goods										
1968:1–1982:3	0.55	0.69	0.023	−0.000478	0.006258	0.107910	−0.001116	0.60		
	(4.38)	(9.37)	(1.00)	(−0.25)	(2.20)	(7.79)	(−0.82)	(4.66)	1.80	0.929
1982:4–1990:4	0.74	0.67	−0.044	0.000363	0.002387	0.090436	0.000917	0.30		
	(2.98)	(6.85)	(−2.61)	(0.07)	(0.25)	(4.87)	(0.43)	(1.23)	1.79	0.968
1968:1–1990:4	0.46	0.75	−0.015	−0.001075	0.007661	0.093841	−0.001692	0.60		
	(4.91)	(15.41)	(−2.66)	(−0.60)	(3.36)	(8.69)	(−1.59)	(5.56)	2.02	0.922
Manufacturing Nondurable Goods										
Food and Kindred Products										
1968:1–1982:3	0.21	0.81	−0.005	0.000193	−0.000364	0.034511	−0.000065			
	(2.03)	(8.31)	(−0.51)	(0.10)	(−0.23)	(3.03)	(−0.05)		1.91	0.563
1982:4–1990:4	0.24	0.74	−0.010	0.000535	0.003917	0.050413	0.001126			
	(2.21)	(8.12)	(−1.34)	(0.22)	(0.98)	(4.46)	(0.47)		2.44	0.974
1968:1–1990:4	0.23	0.79	−0.015	0.000403	0.001068	0.030770	−0.000282			
	(3.26)	(12.26)	(−3.36)	(0.27)	(1.22)	(4.09)	(−0.25)		1.94	0.953
Paper & Allied Products										
1968:1–1982:3	0.74	0.35	0.048	−0.002573	0.007255	0.253640	0.001562	0.90		
	(6.43)	(4.22)	(1.20)	(−2.10)	(2.44)	(8.37)	(1.34)	(12.05)	2.25	0.840
1982:4–1990:4	0.71	0.43	−0.002	−0.002345	0.010222	0.187890	0.001571	−0.10		
	(4.65)	(3.81)	(−0.43)	(−0.57)	(1.97)	(4.63)	(0.71)	(−0.45)	2.01	0.868
1968:1–1990:4	0.72	0.39	0.011	−0.002366	0.009298	0.221810	0.001094	0.80		
	(6.97)	(4.87)	(1.41)	(−1.90)	(3.80)	(8.49)	(1.02)	(10.19)	2.36	0.785
Chemicals and Allied Products										
1968:1–1982:3	0.42	0.77	−0.047	0.001872	0.005559	0.131320	−0.001785	0.30		
	(5.35)	(18.44)	(−3.51)	(0.87)	(2.58)	(10.60)	(−1.45)	(2.14)	2.05	0.949
1982:4–1990:4	0.64	0.61	−0.022	0.004647	0.007039	0.115170	0.003048	0.00		
	(2.81)	(5.33)	(−2.37)	(0.73)	(0.79)	(5.51)	(1.07)	(0.00)	1.91	0.945
1968:1–1990:4	0.45	0.74	−0.019	0.001347	0.003151	0.124050	−0.000913	0.30		
	(5.57)	(17.12)	(−4.37)	(0.62)	(2.17)	(11.28)	(−0.78)	(2.65)	1.91	0.945
Petroleum and Coal Products										
1968:1–1982:3	0.10	0.84	0.002	0.000497	0.004341	0.041708	−0.002785			
	(2.22)	(13.40)	(0.18)	(0.24)	(2.80)	(5.38)	(−2.53)		1.70	0.901
1982:4–1990:4	0.58	0.40	−0.061	−0.010617	0.025814	0.007299	0.001310			
	(3.20)	(2.60)	(−3.42)	(−1.38)	(2.08)	(0.37)	(0.52)		1.87	0.879
1968:1–1990:4	0.08	0.87	0.000076	−0.001782	0.003589	0.032868	−0.000943			
	(2.17)	(19.00)	(0.03)	(−0.69)	(2.70)	(3.63)	(−0.78)		1.78	0.846
Rubber and Plastic Products										
1968:1–1982:3	0.29	0.80	−0.022	0.001622	0.007296	0.246260	−0.002728			
	(4.38)	(15.74)	(−1.37)	(0.55)	(2.29)	(6.06)	(−2.63)		1.48	0.958
1982:4–1990:4	0.18	0.82	−0.005	0.007969	0.016635	0.169780	−0.002325			
	(1.57)	(12.29)	(−0.57)	(1.64)	(2.31)	(5.35)	(−1.71)		2.20	0.968
1968:1–1990:4	0.33	0.76	−0.018	0.001276	0.010258	0.205730	−0.002625			
	(7.25)	(23.40)	(−5.24)	(0.53)	(4.96)	(8.35)	(−3.44)		1.59	0.979

[a]The Expected Sales variable was generated in three steps: 1) Estimated the equation ln Sales = ln b * Time + ln c to create a sales trend based on average percentage growth from one quarter to the next ($ST = \widehat{\ln b} * Time + \widehat{\ln c}$). 2) Corrected for last quarter's deviation of actual sales from the trend by estimating Sales = ST + b(Sales(−1) − ST(−1)). The new corrected sales trend was calculated using the equation S = ST + b(Sales(−1) − ST(−1)). 3) Subtracted actual sales from the corrected sales trend to produce the expected sales variable used in the forward looking equations. (See Bechter and Pollock 1981.)

[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.

T-statistics in parentheses; critical value = 1.993 at the 5% level.

Table A-3 *continued* (4)

Regression Results, Forward Looking

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Expected Sales[a]	Unexpected Sales	Rho[b]	Durbin Watson	Adj. R2
Other Nondurable Goods										
1968:1–1982:3	1.35	0.29	−0.105	−0.003700	0.008338	0.094582	0.001949	0.60		
	(6.53)	(2.63)	(−5.22)	(−2.54)	(3.21)	(6.73)	(1.15)	(4.26)	1.93	0.824
1982:4–1990:4	0.81	0.57	−0.052	0.004419	0.002408	0.072638	−0.000347	0.30		
	(2.90)	(4.08)	(−2.70)	(0.84)	(0.26)	(3.76)	(−0.14)	(1.21)	1.94	0.952
1968:1–1990:4	1.07	0.43	−0.072	−0.003030	0.005475	0.083116	0.000283	0.40		
	(6.91)	(5.25)	(−6.93)	(−2.01)	(3.60)	(7.94)	(0.20)	(3.24)	1.80	0.971
Wholesale										
1968:1–1982:3	0.29	0.76	0.010	−0.000623	0.001331	0.010493	−0.002279	0.20		
	(2.47)	(8.43)	(1.02)	(−0.42)	(0.96)	(5.64)	(−1.95)	(1.09)	2.03	0.844
1982:4–1990:4	0.85	0.36	−0.009	−0.000846	0.003274	0.012161	0.005049	0.60		
	(2.49)	(1.47)	(−0.96)	(−0.25)	(0.40)	(4.08)	(1.90)	(2.05)	2.00	0.601
1968:1–1990:4	0.35	0.72	−0.002	−0.001078	0.002525	0.009900	−0.001839	0.30		
	(3.52)	(9.74)	(−0.74)	(−0.82)	(2.82)	(6.68)	(−1.86)	(2.11)	2.12	0.799
Wholesale Durable Goods										
1968:1–1982:3	0.60	0.66	0.053	0.000038	0.001966	0.046709	−0.001174	0.60		
	(4.33)	(9.01)	(2.36)	(0.02)	(0.69)	(8.01)	(−0.86)	(4.26)	2.29	0.930
1982:4–1990:4	0.83	0.59	−0.023	−0.008176	0.003949	0.032260	−0.000194	0.00		
	(4.04)	(6.94)	(−2.08)	(−1.16)	(0.41)	(5.01)	(−0.06)	(0.00)	2.14	0.959
1968:1–1990:4	0.38	0.78	−0.002	−0.001923	0.008422	0.033585	−0.003374	0.30		
	(5.37)	(21.69)	(−0.64)	(−0.93)	(6.09)	(9.47)	(−2.96)	(2.50)	1.95	0.940
Wholesale Nondurable Goods										
1968:1–1982:3	0.12	0.87	−0.005	0.000303	−0.000467	0.010327	−0.001386			
	(1.73)	(12.24)	(−0.45)	(0.17)	(−0.35)	(2.96)	(−1.28)		2.01	0.845
1982:4–1990:4	0.16	0.81	0.000216	−0.003218	−0.000576	0.008894	−0.000395			
	(1.22)	(5.43)	(0.04)	(−1.04)	(−0.09)	(2.91)	(−0.26)		1.65	0.738
1968:1–1990:4	0.12	0.86	−0.001	−0.000287	−0.001008	0.009783	−0.001219			
	(2.69)	(17.40)	(−0.71)	(−0.20)	(−1.22)	(4.30)	(−1.49)		1.94	0.837
Retail										
1968:1–1982:3	0.23	0.85	0.009	−0.000708	−0.003696	0.012368	−0.002456	−0.10		
	(2.24)	(11.52)	(1.18)	(−0.43)	(−2.70)	(4.79)	(−1.48)	(−0.64)	1.94	0.853
1982:4–1990:4	1.01	0.26	0.008	0.001560	0.016083	0.021617	0.007404	0.80		
	(3.22)	(1.24)	(0.26)	(0.28)	(1.58)	(5.12)	(2.46)	(4.97)	2.00	0.582
1968:1–1990:4	1.02	0.26	0.024	−0.001080	−0.001102	0.018405	0.003886	0.70		
	(5.81)	(2.07)	(3.47)	(−0.79)	(−0.50)	(7.72)	(2.63)	(6.61)	2.19	0.618
Retail Durable Goods										
1968:1–1982:3	0.56	0.74	−0.005	−0.002792	−0.001852	0.059260	−0.001687			
	(3.86)	(9.45)	(−0.24)	(−0.58)	(−0.43)	(5.80)	(−1.01)		2.12	0.842
1982:4–1990:4	1.08	0.49	0.009	0.014260	−0.024136	0.061781	0.006347			
	(4.77)	(4.18)	(0.72)	(1.28)	(−1.49)	(6.40)	(2.14)		1.33	0.727
1968:1–1990:4	0.62	0.70	−0.009	−0.000688	−0.000285	0.058438	−0.000830			
	(5.22)	(11.14)	(−2.01)	(−0.17)	(−0.09)	(8.50)	(−0.59)		1.86	0.843
Auto Dealers										
1968:1–1982:3	0.66	0.59	0.002	0.000363	0.005451	0.077732	−0.001164			
	(4.61)	(5.93)	(0.05)	(0.05)	(0.79)	(4.21)	(−0.73)		2.05	0.769
1982:4–1990:4	0.77	0.55	0.056	0.025766	−0.040068	0.107390	0.004648			
	(3.97)	(3.97)	(1.83)	(1.48)	(−1.54)	(6.03)	(1.55)		1.51	0.851
1968:1–1990:4	0.54	0.68	0.010	0.007836	−0.000651	0.097011	−0.000005			
	(5.55)	(9.84)	(1.18)	(1.29)	(−0.15)	(7.95)	(−0.004)		1.89	0.793

Table A-3 *continued* (5)

Regression Results, Forward Looking

Industry	C	Lagged Dependent	Info Process. Investment/ GDP (−4)	Change in Interest Rate	Inflation	Expected Sales[a]	Unexpected Sales	Rho[b]	Durbin Watson	Adj. R2
Retail Other Durable Goods										
1968:1–1982:3	0.37	0.88	−0.031	−0.005842	−0.004211	0.181570	−0.004458			
	(2.63)	(16.67)	(−1.88)	(−1.64)	(−1.55)	(7.58)	(−2.20)		1.69	0.892
1982:4–1990:4	0.90	0.65	−0.049	−0.007404	0.012487	0.062977	−0.004029			
	(3.10)	(6.79)	(−2.72)	(−0.99)	(1.06)	(2.38)	(−0.92)		2.03	0.956
1968:1–1990:4	0.50	0.82	−0.027	−0.009542	−0.001698	0.123800	−0.005883			
	(4.10)	(18.35)	(−4.00)	(−2.99)	(−0.89)	(6.91)	(−3.20)		1.65	0.964
Retail Nondurable Goods										
1968:1–1982:3	0.35	0.70	0.001	−0.001785	−0.002872	0.018214	0.001259	0.30		
	(2.66)	(6.19)	(0.17)	(−1.84)	(−2.71)	(3.91)	(0.65)	(1.53)	2.02	0.741
1982:4–1990:4	0.68	0.36	0.021	−0.001642	0.007846	0.018534	0.002433	0.60		
	(2.30)	(1.35)	(1.87)	(−0.59)	(1.26)	(2.34)	(0.64)	(3.03)	2.64	0.702
1968:1–1990:4	0.29	0.75	0.008	−0.001540	−0.003317	0.018029	0.000877	0.30		
	(3.53)	(10.25)	(3.14)	(−1.75)	(−3.85)	(4.97)	(0.55)	(2.19)	2.13	0.918
Food Stores										
1968:1–1982:3	0.19	0.69	0.020	−0.000427	−0.000433	0.037242	−0.000188			
	(4.11)	(9.19)	(3.68)	(−0.55)	(−0.71)	(5.55)	(−0.19)		1.69	0.903
1982:4–1990:4	0.25	0.59	0.023	−0.003380	0.000326	0.011745	0.000625			
	(1.95)	(2.91)	(2.17)	(−1.44)	(0.08)	(0.89)	(0.33)		2.36	0.945
1968:1–1990:4	0.20	0.67	0.020	−0.000852	−0.000437	0.029571	0.000059			
	(4.64)	(9.32)	(5.02)	(−1.10)	(−1.06)	(5.02)	(0.07)		1.97	0.980
Retail Other Nondurable Goods										
1968:1–1982:3	0.38	0.74	−0.008	−0.002663	−0.003932	0.027798	0.001699	0.30		
	(2.47)	(7.04)	(−0.66)	(−1.88)	(−2.53)	(3.31)	(0.72)	(1.58)	2.11	0.821
1982:4–1990:4	0.91	0.30	0.007	−0.001651	0.013722	.030712	0.002663	.70		
	(2.89)	(1.35)	(0.61)	(−0.51)	(1.98)	(2.91)	(0.72)	(4.55)	2.37	0.533
1968:1–1990:4	0.31	0.79	0.002	−0.002051	−0.004294	0.027434	0.000673	0.30		
	(3.25)	(11.82)	(1.07)	(−1.65)	(−3.48)	(4.33)	(0.35)	(2.25)	2.07	0.838

[a]The Expected Sales variable was generated in three steps: 1) Estimated the equation ln Sales = ln b * Time + ln c to create a sales trend based on average percentage growth from one quarter to the next (ST = $\widehat{\ln b}$ * Time + $\widehat{\ln c}$). 2) Corrected for last quarter's deviation of actual sales from the trend by estimating Sales = ST + b(Sales(−1) − ST(−1)). The new corrected sales trend was calculated using the equation S = ST + b(Sales(−1) − ST(−1)). 3) Subtracted actual sales from the corrected sales trend to produce the expected sales variable used in the forward looking equations. (See Bechter and Pollock 1981.)

[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.

T-statistics in parentheses; critical value = 1.993 at the 5% level.

Table A-4

Kinked Time Regression Results

1968:1 to 1982:3, 1982:4 to 1990:4

Industry	C	Lagged Dependent	Time	Interactive Dummy (Time * Dummy Variable)	Dummy (82:4 to 90:4 = 1)	Change in Interest Rate	Inflation
Manufacturing & Trade	0.48	0.70	0.000083	−0.001962	0.12	−0.002675	0.001495
	(7.53)	(16.96)	(0.56)	(−4.59)	(4.56)	(−3.05)	(1.42)
Manufacturing	0.41	0.76	0.000034	−0.003517	0.24	−0.003368	0.004943
	(8.99)	(28.16)	(0.18)	(−6.04)	(6.28)	(−3.16)	(3.85)
Durable Goods	0.51	0.75	0.000837	−0.006829	0.44	−0.005443	0.005432
	(10.48)	(32.24)	(2.85)	(−7.60)	(7.65)	(−3.50)	(3.00)
Nondurable Goods	0.23	0.82	−0.000545	−0.000789	0.07	−0.002329	0.004301
	(4.12)	(19.17)	(−4.03)	(−2.06)	(2.70)	(−2.11)	(4.16)
Manufacturing Durable Goods: Primary Metals	0.15	0.92	0.000010	0.001265	−0.12	−0.008593	0.006087
	(2.65)	(35.81)	(0.01)	(0.73)	(−1.09)	(−1.80)	(1.57)
Fabricated Metals	0.52	0.72	0.001976	−0.005909	0.33	−0.001066	0.002447
	(4.55)	(11.16)	(2.41)	(−2.86)	(2.55)	(−0.36)	(0.54)
Machinery, Except Electrical	1.11	0.58	0.000845	−0.023816	1.45	−0.002525	0.012374
	(7.46)	(11.39)	(0.78)	(−6.24)	(6.25)	(−1.46)	(3.48)
Electrical Machinery	1.14	0.49	0.002051	−0.011156	0.69	−0.004013	0.004645
	(7.03)	(6.70)	(2.61)	(−5.08)	(5.06)	(−2.19)	(1.29)
Motor Vehicles & Parts	0.32	0.71	−0.001366	−0.001338	0.10	−0.006174	0.002902
	(5.06)	(10.61)	(−2.50)	(−1.51)	(1.65)	(−1.82)	(0.74)
Other Transportation Equipment	0.75	0.79	0.001939	−0.005840	0.50	0.000776	−0.002133
	(2.95)	(12.53)	(1.42)	(−2.04)	(2.46)	(0.11)	(−0.26)
Other Durable Goods	0.49	0.74	0.000582	−0.003968	0.24	−0.003445	0.003795
	(4.70)	(12.63)	(1.22)	(−2.89)	(2.75)	(−1.82)	(1.38)
Manufacturing Nondurable Goods Food & Kindred Products	0.23	0.79	−0.000140	−0.001071	0.05	−0.000033	−0.000063
	(2.70)	(9.83)	(−0.65)	(−1.70)	(1.33)	(−0.02)	(−0.05)
Paper & Allied Products	0.26	0.79	0.000279	−0.000293	0.01	−0.003014	0.002339
	(6.40)	(23.83)	(1.24)	(−0.70)	(0.52)	(−1.89)	(1.54)
Chemicals & Allied Products	0.33	0.84	−0.001354	0.000278	0.02	−0.000009	0.001796
	(4.12)	(19.51)	(−3.66)	(0.40)	(0.33)	(−0.00)	(0.73)
Petroleum & Coal Products	0.17	0.75	−0.000072	−0.002203	0.18	−0.002808	0.004870
	(3.51)	(11.70)	(−0.22)	(−2.57)	(2.98)	(−1.10)	(2.37)
Rubber & Plastic Products	0.25	0.83	−0.000122	−0.000933	0.03	0.000667	0.004089
	(4.73)	(20.77)	(−0.37)	(−1.17)	(0.70)	(0.28)	(1.62)
Other Nondurable Goods	1.26	0.32	−0.002429	−0.005034	0.31	−0.003936	0.007265
	(7.19)	(3.59)	(−2.80)	(−2.93)	(2.95)	(−2.99)	(2.56)
Merchant Wholesalers	0.98	0.29	0.000390	−0.001997	0.11	−0.001114	−0.004096
	(6.99)	(2.81)	(0.65)	(−1.48)	(1.32)	(−1.05)	(−1.81)
Wholesale Durable Goods	0.32	0.85	0.000660	−0.001334	0.04	−0.003229	−0.003378
	(4.87)	(26.34)	(2.24)	(−1.84)	(0.93)	(−1.47)	(−1.67)
Wholesale Nondurable Goods	0.90	0.04	−0.001900	0.003341	−0.19	−0.000446	−0.002704
	(7.45)	(0.29)	(−2.71)	(2.23)	(−2.02)	(−0.40)	(−1.17)
Retail Trade	0.56	0.63	0.000502	0.000436	−0.04	−0.000859	−0.004717
	(5.71)	(8.97)	(2.41)	(0.87)	(−1.16)	(−0.55)	(−3.24)
Retail Durable Goods	0.84	0.61	0.000763	−0.001311	0.01	−0.004474	−0.004345
	(6.10)	(8.57)	(1.34)	(−1.08)	(0.15)	(−0.99)	(−1.01)
Automotive Dealers	0.82	0.50	0.001115	0.003972	−0.35	−0.000351	0.002022
	(6.34)	(5.70)	(1.25)	(1.89)	(−2.41)	(−0.05)	(0.31)
Other Durable Goods	0.59	0.81	−0.000023	−0.004039	0.23	−0.007460	−0.009074
	(4.84)	(18.12)	(−0.07)	(−3.87)	(3.58)	(−2.57)	(−3.43)
Retail Nondurable Goods	0.33	0.73	−0.000116	0.000717	−0.03	−0.001588	−0.002899
	(5.15)	(13.33)	(−0.92)	(2.14)	(−1.59)	(−1.83)	(−3.94)
Food Stores	0.23	0.79	−0.000140	−0.001071	0.05	−0.000033	−0.000063
	(2.70)	(9.83)	(−0.65)	(−1.70)	(1.33)	(−0.02)	(−0.05)
Other Nondurable Goods	0.53	0.65	−0.000634	0.001303	−0.06	−0.002470	−0.003723
	(2.62)	(4.61)	(−1.53)	(1.41)	(−1.21)	(−2.02)	(−2.39)

Table A-4 *continued*

Kinked Time Regression Results

1968:1 to 1982:3, 1982:4 to 1990:4

Unexpected Sales	Percent Change in Sales[a]	Rho[b]	Durbin Watson	Adjusted R2
−0.005125	−0.014	0.30		
(−8.38)	(−8.91)	(2.54)	2.07	0.966
−0.006596	−0.017	0.30		
(−12.59)	(−11.70)	(2.62)	2.02	0.988
−0.007833	−0.024	0.30		
(−14.96)	(−14.97)	(2.70)	1.95	0.990
−0.006803	−0.007			
(−7.88)	(−4.45)		1.96	0.978
−0.009847	−0.025			
(−12.17)	(−13.79)		1.64	0.981
−0.006166	−0.027	0.50		
(−6.78)	(−9.53)	(4.31)	2.09	0.919
−0.006862	−0.032	0.80		
(−7.49)	(−12.65)	(13.04)	2.23	0.970
−0.004298	−0.027	0.70		
(−4.45)	(−11.48)	(7.32)	1.95	0.888
−0.003277	−0.011			
(−8.34)	(−11.45)		2.08	0.949
−0.013558	−0.048	0.30		
(−7.40)	(−7.81)	(2.44)	2.15	0.906
−0.006581	−0.019	0.50		
(−8.37)	(−7.86)	(4.23)	1.89	0.937
−0.002234	−0.007			
(−2.17)	(−2.86)		1.97	0.949
−0.006026	−0.016			
(−6.76)	(−9.57)		1.84	0.955
−0.007885	−0.021	0.30		
(−8.80)	(−10.23)	(2.58)	1.94	0.946
−0.002892	−0.007			
(−3.21)	(−3.29)		1.75	0.853
−0.006030	−0.013			
(−9.47)	(−8.48		2.05	0.980
−0.002032	−0.019	0.80		
(−1.91)	(−7.74)	(10.01)	1.87	0.852
−0.001266	−0.019	0.80		
(−1.57)	(−9.06)	(9.83)	2.10	0.636
−0.008432	−0.019			
(−7.60)	(−10.32)		1.74	0.965
0.000274	−0.011	0.80		
(0.47)	(−6.34)	(10.75)	1.84	0.388
−0.004306	−0.018			
(−3.75)	(−6.69)		1.94	0.898
−0.005736	−0.022			
(−4.79)	(−6.84)		2.15	0.822
−0.004199	−0.018			
(−3.59)	(−5.21)		2.08	0.748
−0.010560	−0.027			
(−7.71)	(−9.06)		1.78	0.971
−0.002719	−0.015			
(−2.19)	(−6.56)		1.55	0.958
−0.002234	−0.007			
(−2.17)	(−2.86)		1.97	0.949
−0.002633	−0.016	0.40		
(−1.77)	(−4.09)	(2.11)	2.10	0.799

[a]Polynomial Distributed Lag (first degree polynomial, 3 quarters including current quarter, far endpoint constraint).

[b]Estimated using the Hildreth-Lu method for correcting first order serial correlation.

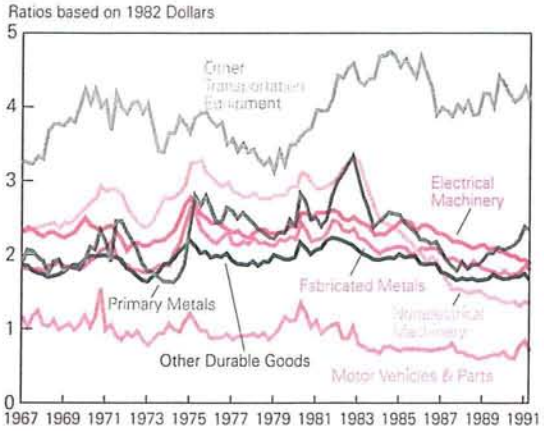
Coefficients shown are the sum of the estimated lagged coefficients.

T-statistics in parentheses; critical value = 1.993 at the 5% level.

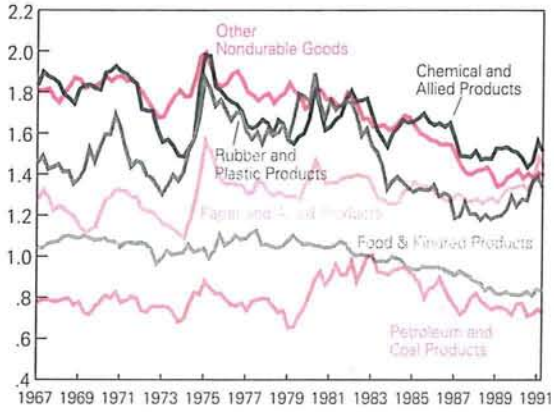
Figure A-1

Inventory-to-Sales Ratios

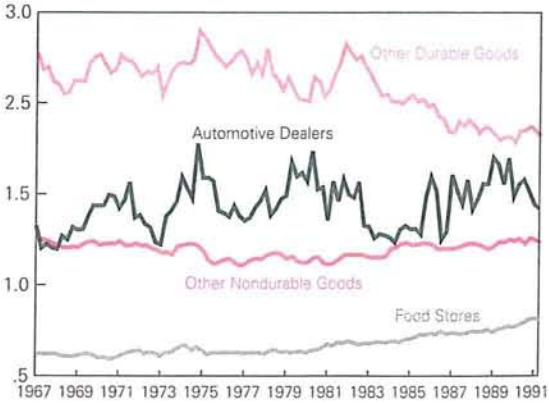
Durable Goods Manufacturing: Selected Industries



Nondurable Goods Manufacturing



Retail Trade



Quarterly data, seasonally adjusted.
Shaded areas represent recessions.
Source: U.S. Bureau of Economic Analysis.

Table A-5
Standard Deviation of Inventory-to-Shipments Ratio
by Industry, by Size of Firm

Industry	1977 Mean	1977 Standard Deviation	1982 Mean	1982 Standard Deviation	1987 Mean	1987 Standard Deviation
Manufacturing Nondurable Goods						
Food and Kindred Products	0.973	0.133	1.008	0.139	0.885	0.117
Tobacco Products	4.201	1.260	4.971	0.973	2.678	1.693
Textile Mill Products	1.645	0.225	1.760	0.348	1.575	0.346
Apparel and Fabrics	1.562	0.240	1.602	0.186	1.621	0.132
Lumber and Wood Products	1.375	0.128	1.630	0.135	1.178	0.208
Furniture and Fixtures	1.876	0.186	1.924	0.164	1.673	0.123
Paper and Allied Products	1.325	0.090	1.453	0.152	1.273	0.127
Printing, Publishing, and Allied Industries	0.970	0.154	0.971	0.190	0.833	0.168
Chemicals and Allied Products	1.462	0.090	1.662	0.120	1.357	0.074
Petroleum Refining and Related Industries	0.723	0.124	0.949	0.144	0.835	0.125
Manufacturing Durable Goods						
Rubber and Miscellaneous Plastics Products	1.449	0.128	1.540	0.227	1.210	0.424
Leather and Leather Products	1.754	0.329	1.778	0.741	1.585	1.135
Stone, Clay, Glass, and Concrete Products	1.391	0.375	1.572	0.724	1.075	0.607
Primary Metal Industries	1.879	0.284	2.471	0.536	1.704	0.626
Fabricated Metal Products	1.959	0.354	2.112	0.387	1.581	0.604
Industrial and Commercial Machinery	2.444	0.536	2.771	0.570	2.066	0.761
Electronic and Other Electrical Equipment	2.214	0.155	2.428	0.090	1.433	0.946
Transportation Equipment	2.033	0.260	2.280	0.359	1.069	0.905
Measuring, Analyzing, and Controlling Instruments	2.491	0.317	2.629	0.304	2.266	0.786
Miscellaneous Manufacturing Industries	2.157	0.270	2.324	0.158	1.291	1.061

Source: U.S. Bureau of the Census, *Census of Manufactures.*

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