FRBSF WEEKLY LETTER

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Just-In-Time Inventory Management: Has It Made a Difference?

Inventory investment is a closely watched cyclical indicator, even though it is normally only a small portion of real GDP. It is valuable as an indicator because it is so volatile in the short run that it often accounts for much of the volatility in real GDP. Indeed, since World War II, declines in inventory investment have accounted for over 70 percent of declines in real GDP during recessions, on average. Therefore, an unusual buildup of inventories may be viewed as a precursor of an economic slowdown, as firms cut back production to eliminate unwanted inventories, while a rapid inventory drawdown suggests just the opposite. This framework assumes that there is a benchmark or "normal" level of inventories held by businesses relative to sales or output, and that an unusual deviation in the inventory-to-sales ratio relative to its long-run value might be viewed as indicating a change in the cyclical phase.

Recently, the business press and management literature have focused much attention on the adoption of the "just-in-time" (JIT) inventory technology in the U.S. during the 1980s, which lets firms operate with a significantly lower inventory-to-sales ratio. It is argued that the widespread adoption of JIT has lowered the normal level of inventories in the U.S.

This *Letter* examines whether there has been a significant downward shift in the business sector's inventory holdings relative to sales in the 1980s, and finds that the evidence is not as clear as some observers claim. In fact, the analysis suggests that the relationship between inventory investment and its key economic determinants changed little during the 1980s.

The upside and downside of JIT

A number of case studies have described the adoption of JIT inventory management techniques by U.S. firms, and two stories will serve to illustrate its upside and its downside. On the upside, the *Journal of Purchasing and Materials Management* (1987) reported the experiences of Harley-Davidson, the motorcycle firm. According to the article, the company was driven to the verge of bankruptcy by its Japanese competitors, who practiced JIT. Harley-Davidson lobbied for a temporary trade barrier, and while the trade protection was in place, it adopted JIT, which contributed to its recovery and eventual re-emergence as a competitive business.

The downside risks of JIT are illustrated by the experience of a California computer producer in the mid-1980s. In this case, the firm's assembly plant received parts on a weekly JIT basis from a supplier in the Far East. But when one shipment of parts turned out to be defective, the operations of the entire plant came to a halt, and activity throughout the chain of sales and distribution was disrupted for a couple of weeks. To correct the situation the company had to send executives to the parts supplier and had a special shipment of parts air-freighted (Ramey 1989). This example illustrates that JIT does not necessarily always offer an unambiguous net benefit to all firms.

Measurement problems

The inventory-to-sales (IS) ratio is a commonly observed measure of inventory behavior. The particular IS ratio considered here measures the existing stock of inventories relative to sales of the manufacturing and trade sectors. In considering the IS ratio, it is important to note that inventories in the manufacturing sector are made up of goods in various stages of production, and it is difficult to obtain a precise measurement of inventories in the earlier stage. The inventories consist of goods in three stages: materials and supplies, work-in-progress, and finished goods. As of the late 1980s, finished goods accounted for less than 30 percent of the manufacturing sector's total inventory holdings, while materials and supplies and work-in-progress made up about 40 and 30 percent, respectively.

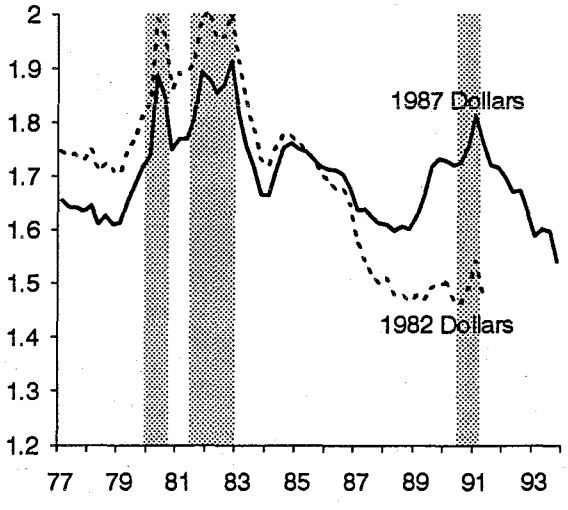
The case of the automobile industry can be used to illustrate the problem in obtaining good constant dollar estimates of inventories, which are not affected by changes in the prices over time. First, data become available on the *nominal*

values of the inventories in each stage of production. To arrive at the constant dollar values, the proper price deflator must be applied to the nominal values. This step is particularly difficult for inventories in the earliest stages of production—materials and supplies. For the auto industry these inventories consist of items such as tires, metal frames, and computer chips. To measure the constant dollar value of such diverse items accurately, the price deflator must incorporate individual input factor prices, as well as their share in the total stock of materials and supplies. The necessary information on the mix of input factors in producing a particular product is rather limited. As a consequence, analysts use "input-output" tables, which show how much and what type of input factors typically are required to produce a particular type of output.

New vs. old measures of the IS ratio

In early 1993 the Bureau of Economic Analysis released a benchmark revision to the inventory and sales data. The revision had an important effect on estimates of the IS ratio data, as illustrated in Figure 1. The revised IS ratio is measured in 1987 dollars, and it reflects the input-output table as of 1982, whereas the pre-revision IS ratio was based on the input-output table of 1967, and is measured here in 1982 dollars. Both the new and the old measures show similar cyclical patterns. They rise markedly just before business cycle peaks; they continue to rise during subsequent contractions (shaded periods in Figure 1), and then they tend to fall in expansions.

Figure 1
Manufacturing IS Ratios



During the second half of the 1980s, however, the two measures exhibit different patterns with regard to the secular trend. The ratio measured in 1982 dollars shows a sharp decline in the late 1980s, suggesting shift in the *levels* of inventories. This would support the view that JIT is playing a big role in inventory management. However, a downward trend is less obvious in the revised data.

Part of the explanation for the upward revision in the IS ratio in the 1980s is that, since the revised input-output table is more detailed, it better reflects the technology components in the production mix. Integrated computer chips, for example, common in today's automobiles, were not used in cars produced in the late 1960s. Furthermore, the new IS estimates also reflect the significant price declines in computing equipment during the 1980s. Under the old measure, the constant dollar value of the inventories of computer chips for 1987 were underestimated because they were deflated by a higher 1982 price.

Based on these considerations, the 1987 constant dollar IS ratio is more reliable than the one measured in terms of the 1982 constant dollar. The IS ratio measured in current dollars is a potentially useful alternative. However, the amplitude of fluctuations in the current dollar IS ratio around recessions is very big and hence it is hard to discern a change in the long term trend.

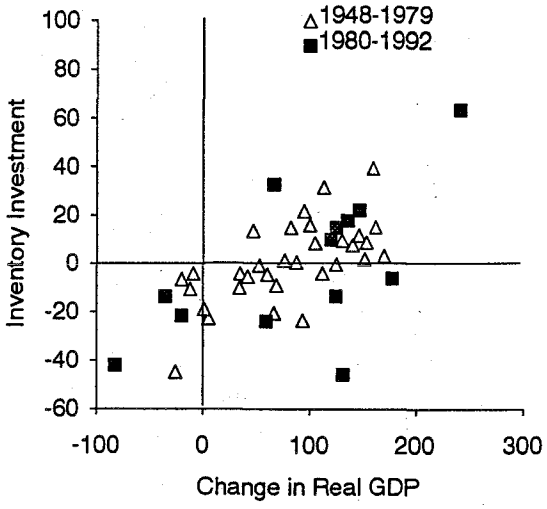
The IS ratio examined so far is limited to the manufacturing and trade sectors. For a more complete analysis, we need to look at aggregate inventory behavior. Also, a more systematic examination of the dynamic relationship between inventory investment and related variables is needed to see whether there has been a shift in the responsiveness of inventories to changes in their economic determinants.

Behavior of aggregate inventory investment

Is there a stable long-term relationship between aggregate inventory investment and changes in aggregate output over time? Such a relationship offers a frame of reference for comparing the pattern of aggregate inventory investment since 1980. Indeed, a simple relationship between inventory investment and output growth has been observed for a number of years. Namely, the ratio between the aggregate inventory investment and the annual change in real GDP remains stable over time (see, for example, Hall and Taylor 1991). Based on this relationship, it will be useful

to see whether the observations in the 1980s, the period when JIT would have had the most impact, align with the general historical pattern between inventory investment and changes in output. Figure 2 presents the scatter plots of the two variables where the observations from 1948 to 1980 are marked by triangles and the observations since 1980 are marked by squares. The results do not support the contention that there has been a significant downward shift in inventory due to an improvement in inventory management techniques, because the post-1980 observations, as a group, are not different from the pattern seen in the observations for the earlier period.

Figure 2
Inventory Investment and Change in Real GDP



This informal test is confirmed by econometric analysis (of a vector autoregression), which models the change in real GDP, inventory investment (both measured in 1987 dollars), consumer price inflation, and the 6-month commercial paper rate (the results are available from the author upon request). The latter two variables are included to capture the effects of inventory financing costs. Two identically specified econometric models were estimated for the periods 1959.Q2–1980.Q4 and 1959.Q2–1989.Q4. If there had been a significant shift in the relationship during the 1980s, the model covering the whole sample period would have been different from the first one estimated using data from 1959–1980. However, the dynamic behavior of the two models in response to an unforeseen change in output, or in the interest rate, is not substantially different across the two models.

Next, the dynamic simulations from the two models were examined to see whether there was a significant divergence. Both models were used to forecast inventory investment for 1994 through 1996 conditioned on the same set of information. The difference in the forecasts from the two models is quite small and statistically insignificant. In other words, the model estimated from the sample that includes the additional 10-year period from the 1980s is not materially different from the model estimated from the shorter sample.

Conclusion

The relationship between aggregate inventory investment and its key determinants does not appear to have shifted significantly since 1980. This finding does not deny that there have been technological developments in the area of inventory management, especially in manufacturing. However, the effect of any improvement in inventory management is not discernible in either the manufacturing sector or the aggregate real inventory investment data to this point.

Chan Huh
Economist

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Research Department
Federal Reserve
Bank of
San Francisco

P.O. Box 7702
San Francisco, CA 94120

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Index to Recent Issues of *FRBSF Weekly Letter*

DATE	NUMBER	TITLE	AUTHOR
11/5	93-38	Real Interest Rates	Trehan
11/12	93-39	A Pacific Economic Bloc: Is There Such an Animal?	Frankel/Wei
11/19	93-40	NAFTA and the Western Economy	Schmidt/Sherwood-Call
11/26	93-41	Are World Incomes Converging?	Moreno
12/3	93-42	Monetary Policy and Long-Term Real Interest Rates	Cogley
12/17	93-43	Banks and Mutual Funds	Laderman
12/31	93-44	Inflation and Growth	Motley
1/7	94-01	Market Risk and Bank Capital: Part 1	Levonian
1/14	94-02	Market Risk and Bank Capital: Part 2	Levonian
1/21	94-03	The Real Effects of Exchange Rates	Throop
1/28	94-04	Banking Market Structure in the West	Laderman
2/4	94-05	Is There a Cost to Having an Independent Central Bank?	Walsh
2/11	94-06	Stock Prices and Bank Lending Behavior in Japan	Kim/Moreno
2/18	94-07	Taiwan at the Crossroads	Cheng
2/25	94-08	1994 District Agricultural Outlook	Dean
3/4	94-09	Monetary Policy in the 1990s	Parry
3/11	94-10	The IPO Underpricing Puzzle	Booth
3/18	94-11	New Measures of the Work Force	Motley
3/25	94-12	Industry Effects: Stock Returns of Banks and Nonfinancial Firms	Neuberger
4/1	94-13	Monetary Policy in a Low Inflation Regime	Cogley
4/8	94-14	Measuring the Gains from International Portfolio Diversification	Kasa
4/15	94-15	Interstate Banking in the West	Furlong
4/21	94-16	California Banks Playing Catch-up	Furlong/Soller
4/29	94-17	California Recession and Recovery	Cromwell

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