

Donald S. Allen is an economist at the Federal Reserve Bank of St. Louis. Thomas A. Pollmann provided research assistance.

Changes in Inventory Management and the Business Cycle

Donald S. Allen

"I remember one day in the summer of 1975 when a CBO [Congressional Budget Office] staffer returned from a congressional hearing with some amazing news. Alan Greenspan, then President Gerald Ford's chief economic adviser, had just testified that the recession was mostly an inventory correction. We all snickered at the idea that what was, up to then, the deepest recession since the Great Depression could have been 'only' an inventory cycle. When I subsequently studied the data more carefully, however, I learned that Greenspan had been right. Like most of the recessions before and since, the 1973-5 contraction was dominated by changes in inventory investment."

Alan S. Blinder, introduction to *Inventory Theory and Consumer Behavior* (1990)

The change in business inventories is usually less than 1 percent of total Gross Domestic Product (GDP), yet during cyclical contractions this component contributes disproportionately to the change in GDP. As a result, most cyclical contractions have been referred to as inventory cycles. These inventory cycles are characterized by an unanticipated drop in demand resulting in unplanned increases in inventories. Firms respond by cutting production to reduce inventory. This cut in production can exacerbate the downturn by reducing demand further.

Since the 1970s, many firms have made notable changes in their inventory management methods. In particular, large movements in interest rates in the early 1980s and increased global trade have combined to motivate firms to reduce inventory levels relative to sales as part of larger downsizing efforts. More efficient inventory management has been realized by implementing "just-in-time" (JIT) management techniques and the use of bar codes. Will these innovations in inventory management decrease the effect of inventory movements on the business cycle? This article investigates the extent of the changes in inventory management and makes some observations regarding inventory movement and the business cycle. There is evidence to suggest that the use of these innovative inventory control methods is on the rise, but the net effect on the business cycle remains ambiguous.

In the first two sections, I review the role of inventory investment in postwar recessions and the motivations for holding inventory. Next, I document some of the innovations in inventory management that firms have adopted over the last 10-15 years. Finally, I discuss the potential impact of these changes on the business cycle.

THE ROLE OF INVENTORY IN POSTWAR RECESSIONS

The stocks of materials and supplies, partially completed goods and finished goods in the possession of a firm are income-producing assets. These stocks are held temporarily before being sold. As inventories are increased or decreased between the beginning and the end of a period, they add to or subtract from the investment component of GDP. Unlike fixed investment, which is assumed to be the result of specific plans by firms, inventory stocks fluctuate as a result of both active decisions by firms and errors in forecasted demand. This dual effect tends to make inventory investment especially volatile around contractions, usually going

Table 1

U.S. Inventory Investment Movements in Postwar Recessions

Recession Period Peak to Trough ¹	Change in Real GDP ²	Change in Inventory Investment ²	Change in Inventory Investment as a Percentage of Change in Real GDP
1948:4 - 1949:4	-14.5	-28.3	195.2
1953:2 - 1954:2	-36.9	-20.0	54.2
1957:3 - 1958:1	-61.1	-21.1	34.5
1960:1 - 1960:4	-15.8	-45.5	288.0
1969:3 - 1970:4	-11.2	-32.2	287.5
1973:4 - 1975:1	-135.1	-84.7	62.7
1980:1 - 1980:2	-98.2	-10.7	10.9
1981:3 - 1982:3	-110.1	-35.0	31.8
1990:2 - 1991:1	-75.1	-44.5	59.3
Mean			113.8

¹ Peaks and troughs correspond to peaks and troughs of real GDP and do not always coincide with official NBER recession dates.

² Billions of 1987 dollars.

from positive at the beginning as a result of unintended accumulation, to negative due to deliberate reduction.

Inventory investment averages less than 1 percent of GDP, but changes in inventory investment can account for a substantial portion of the *change*. In 1994, for example, inventory investment was \$47.8 billion (in 1987 dollars) or 0.9 percent of GDP. This level of inventory investment reflected an increase of \$32.5 billion over 1993 or 15.5 percent of the \$209.5 billion increase in GDP in 1994.

The typical inventory cycle begins with an unexpected reduction in demand which leaves firms with inventory above their desired levels. Production is reduced to lower inventory levels, which can result in layoffs and further reduction in demand. As inventory falls back to desired levels and demand resumes, production may be insufficient to meet demand and maintain inventory levels. The result is that inventory can fall

below the desired level, causing increased production to replenish inventory. The degree of undesired accumulation and decumulation is a function of the accuracy of firms' demand projections. This inventory cycle phenomenon has been of varying interest to economists, and research in this area has ebbed and flowed like the business cycle. Metzler (1941) showed analytically how inventory cycles could be generated when decisions on production levels are based on expected levels of sales, and income and demand are determined by production levels. Blinder and Maccini (1991) provide a good survey and bibliography of research in inventory cycles since Metzler's work.

The role of inventory investment in business cycle contractions has been well documented. Coincident declines in GDP and inventory investment are empirical regularities of postwar business cycles. Blinder and Maccini (1991) show that the average movement in inventory investment during recessionary periods in the postwar era account for 87 percent of Gross National Product (GNP) movement from peak to trough. Computed another way, the relative movement is even greater. Table 1 shows peak-to-trough movement in inventory investment compared to the peak-to-trough change in GDP in all postwar recessions.¹ The average percentage change in inventory investment to change in GDP is 113.8 percent. Admittedly, this method computes the difference between the highest quarterly increase in business inventory and the highest quarterly decrease in business inventory on an annualized basis, capturing the widest swing. However, it is evident that inventory investment has been a significant contributor to changes in GDP during contractions. Figure 1 compares the change in GDP and the change in business inventories since 1948. Recessions are shown by shaded bars.

Inventory level movement by itself is not the complete story. It is necessary to know whether movements are active responses to changes in the level of demand or reflect errors in forecasting. The ratio of inventory to sales, defined as total stocks divided by monthly sales, gives some indication of the nature of these movements. If we assume

¹ The National Bureau of Economic Research (NBER) typically has identified a recession as a period with two consecutive quarters of decline in GDP. The peak of the cycle is the quarter prior to the first quarter of decline. The trough is the last quarter of negative growth. The peak-to-trough movement in inventory investment in Table 1 is the difference between the maximum and minimum inventory investment during the recession period.

that firms plan to maintain a relatively constant level of inventory to sales, major deviations in this ratio can give clues to whether movements are planned or unplanned. If inventory accumulation is accompanied by an increasing inventory-to-sales ratio, then the accumulation may be inadvertent because inventory is rising faster than sales. If inventory accumulation is accompanied by a constant inventory-to-sales ratio, then the accumulation may have been planned in response to increasing sales. An increase in inventory can also be accompanied by a decrease in the inventory-to-sales ratio, indicating that sales are increasing faster than inventories.

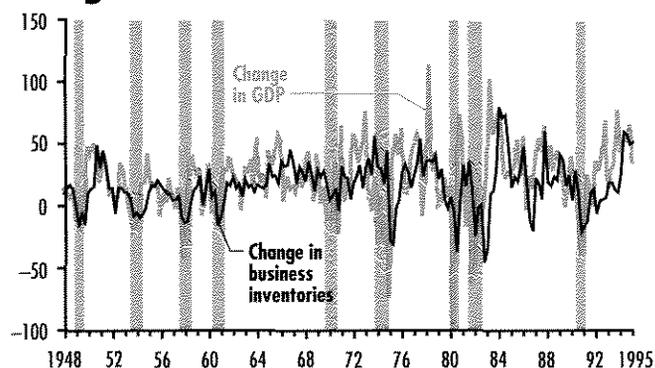
The total business inventory-to-sales ratio in the postwar period is shown in Figure 2, with recessions indicated by shaded bars. It is also evident from this figure that the ratio peaks around the contractions, making it a relatively reliable coincident indicator. Although it cannot be claimed that inventory changes cause the business cycle, any imbalance which occurs between expected and actual sales shows up in inventory, and correcting this imbalance can exacerbate the cycle. Even if we do not consider inventory investment to be a causative force but simply a barometer of forecast accuracy, most recessions appear to be marked by an inventory correction.

WHY HOLD INVENTORY IN THE FIRST PLACE?

Inventory stocks represent a major utilization of resources. At the end of 1994, manufacturing and trade inventories totaled \$832 billion (1987 dollars) or 12.4 percent of annual sales. At the current prime rate, the opportunity cost of holding the 1994 level of inventory stocks amounts to more than \$70 billion. This financing cost compares to the 1994 annual increase in GDP of roughly \$200 billion. The capital tied up in financing inventory could also be converted into fixed investment in more productive capital equipment. But rational firms are motivated to hold inventory as long as the expected cost of holding it is less than the expected penalty

Figure 1

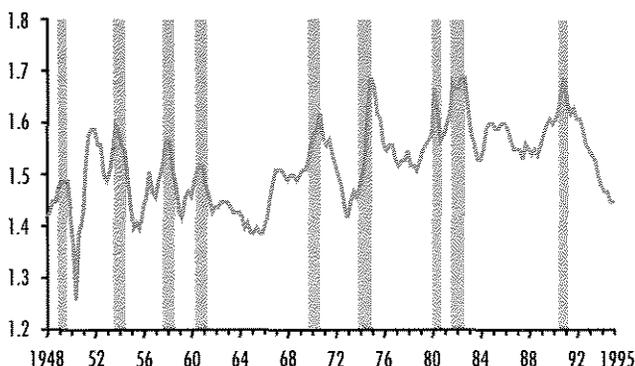
Change in GDP Compared to the Change in Business Inventories



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis.

Figure 2

Total Business Inventory-to-Sales Ratio



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis.

(lost revenue or market share) for running out of stock. In other words, the optimal level of inventory in the face of uncertain sales and random supply interruption is not always zero, and there is a limit to the savings which can be realized by lowering inventory.

The motivations for holding inventories are diverse and firm-specific. Some firms minimize their delivery costs, some smooth production in the face of uncertain demand, and others stockpile against potential interruptions or anticipated price increases by suppliers. Most retailers are forced to hold inventory to accommodate the

INVENTORY MODELS

Production Smoothing

The accompanying figure on page 21 illustrates the production smoothing motivation when increasing marginal costs exist. If Q_1 and Q_2 represent the demand in periods 1 and 2, respectively, then point A represents the average cost if Q_1 is produced in period 1 and Q_2 is produced in period 2. Point B represents the average cost if $(Q_1+Q_2)/2$ is produced in both periods, with the excess produced in period 1 carried over to period 2. The trade-off is between the cost of storage for one period versus the saving from smoothing.¹ The difference between A and B must be greater than the cost of holding inventory to justify smoothing. Note also that if mean demand is expected to decrease below current production for an extended period (that is, Q_2 is current demand and Q_1 is next period's expected demand), then it becomes optimal to reduce production and serve part of current demand from inventory. Thus, production smoothing motivation can lead to level changes if forecast sales change direction.

¹ Holt, Modigliani, Muth and Simon (1960) provide the details of the production smoothing model.

² Scarf (1960) proves the optimality of the (S,s) rule under specific conditions.

wide range of preferences and sizes of consumers. Generally, inventories are a hedge against uncertainty or a means of minimizing production costs.

There are two competing models for inventory decisions, depending on the assumption about production costs. When firms operate in a region of increasing marginal costs, it becomes more economical to smooth production than to adjust to changing sales. When marginal costs are constant, but there are fixed costs associated with delivery or production, batch runs or bunching spread these fixed costs over larger quantities. (See the shaded insert above for discussion.) Wholesalers, retailers and manufacturing purchasers of raw materials and supplies are more likely to face non-negligible delivery costs and therefore more likely to use batch purchasing.

(S,s) Rule

If costs are linear, as in the case when marginal costs are constant, and there is a significant fixed cost of purchasing in each period, then it can be shown that "lumpy" adjustment is preferred to smoothing. An economic batch run, or a purchase which minimizes the total expected cost including the cost of storage of excess inventory, and the cost of lost sales can be determined. The inventory management technique used under these circumstances is referred to as (S,s) and entails determining maximum (S) and minimum (s) levels of inventory.² When inventories fall below (s), purchases are made to bring inventory up to (S), as long as inventories are between (S) and (s), nothing is done. The (S,s) parameters will define the upper and lower bound of inventory movement. It can be shown that the (S,s) margin is more sensitive to the mark-up of price over marginal cost than to interest rates.

INVENTORY INNOVATIONS

Is JIT Changing the Face of Inventory in America?

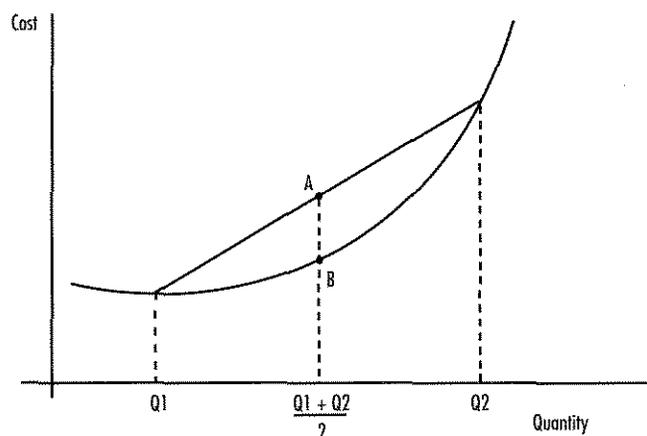
As businesses focused on streamlining operations in the 1980s, one of the targets has been inventory stocks. Over the last 15 years, there seems to have been major shifts in the methods used to manage inventory. In particular, many U.S. companies have studied and adopted the Japanese *kanban* (or JIT) method of inventory management. The objective of the JIT system is to minimize the stock of parts and components by having them delivered just in time for production, and to limit the inventory of finished goods by producing them just in time to fill demand. The monthly National Association of Purchasing Management survey indicates that as much as 26 percent

Just-in-Time Inventory

Just-in-time (JIT) inventory control attempts to match production as closely to sales as possible and thereby minimize the costs of holding inventory. This method, called *kanban* in Japan, is characteristic of Japanese industry in general and the auto industry in particular. JIT can be optimal when convex costs of production exist but storage costs exceed savings from smoothing or when linear costs exist but the low mark-up, low variance of sales, low fixed costs of delivery or high costs of storage result in low values of (S,s) . If firms can meet demand without holding inventories, then inventories become superfluous. JIT can exist only in an atmosphere in which suppliers are reliable enough to minimize the risk of stock-outs. Larson (1991) argues that deregulation of the transportation industry has resulted in innovations which

foster the use of JIT. Intuitively, deregulation, which reduces the economic lot-size of shipment, allows more continuous streams of shipment.

Convex Production Cost



of the respondents reported purchasing materials “hand to mouth” in January 1995, compared to as little as 4 percent in February 1970. This suggests that the JIT philosophy has made major inroads into U.S. manufacturing. Bechter and Stanley (1992) find empirical evidence of improved inventory control along with faster speeds of adjustment to desired inventory levels.

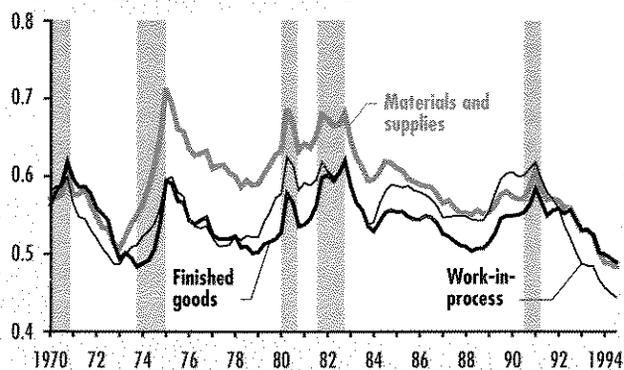
Prima facie evidence of the success in reducing manufacturing inventory is also seen in the consistent decline in the aggregate inventory-to-sales ratio (shown in Figure 2), which has dropped from a peak of approximately 1.7 during the 1990 recession to 1.44 in December 1994 — the lowest in about 20 years. The manufacturing sector has been reducing inventory at all stages of production. Figure 3 shows the manufacturing sector inventory-to-sales ratios by

stage of processing for 1970 to 1994. The work-in-process and materials and supplies are at a low point for the last two decades, after a steady decline since the early '80s. Some of this decline may be attributable to factors other than JIT. For instance, a closer look shows that materials and supplies increased rapidly relative to sales during the 1973-75 recession and did not return to earlier levels until recently. This could indicate an end to a post-oil-embargo tendency to stockpile, motivated by inflation expectations and sensitivity to interruptions.

Some industries have been more successful than others in lowering inventory levels relative to sales. Table 2 shows the summary statistics for the inventory-to-sales ratio by stage of processing for four manufacturing industries which have experienced significant declines in ratio. The December 1994 ratio is

Figure 3

Manufacturing Inventory-to-Sales Ratios by Stage of Processing



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis.

provided for comparison. Motor vehicle materials and supplies, and work-in-process inventory stocks have declined from peak ratios of over 70 percent of monthly sales each to 19 percent and 14 percent, respectively, in December 1994. In all four industries and for all stages of processing, December ratios are well below the mean for the entire period.

The use of JIT tends to shift the burden of responding to uncertainty to the suppliers and to require speedy delivery methods.² Some analysts believe that significant changes in the transportation industry, fostered in part by deregulation and increased competition, contributed to the viability of JIT. In particular, if a manufacturer wishes to maintain a continuous flow of materials, deliveries must take place more often in smaller batches. The deregulation in the trucking industry, which allowed competitive pricing for less-than-truckload deliveries, and increased competition in air freight help reduce the cost of smaller, more frequent deliveries.

JIT in the Auto Industry

The evolution of the structure of the U.S. automobile industry is relatively unique and was motivated primarily by the need to smooth production, combined with a limited ability to hold inventory (see Olney, 1989). The relationship between manufacturers, wholesalers and retailers ensures that the storage of finished goods occurs primarily at

the retail and wholesale levels. The cost of financing high levels of inventory is a major cost of doing business. In the early years of the industry, finance companies took on the dual role of providing credit to wholesalers and buying consumer loans initiated by dealers. It seems appropriate, therefore, that the push to reduce inventory levels should take place in the auto industry. Minimizing inventory reduces financing needs and thus increases the competitive edge. The downside is greater vulnerability to interruptions such as strikes or to unanticipated surges in demand. U.S. automobile manufacturers appear to have embraced JIT and currently hold less than two weeks worth of sales in inventory, down from a high of 1.3 months.

Figure 4 shows the changes in inventory-to-sales ratios in the motor vehicle industry by stage of processing for the period 1970-94. It is apparent that there has been much success in reducing inventory levels over the last 10 years.

Figure 4 also reveals that the reduction occurred primarily at the work-in-process, and materials and supplies stages of production with very little change in the level of finished goods relative to sales. The burden of reduced inventory has been placed on the intermediate input stage of production.

As an example of the downside of lower inventory holdings, however, General Motors in 1994 experienced the shutdown of several assembly lines because of an interruption at a drivetrain component plant. If they had held higher levels of inventory, they would have been able to reduce the scale of the shutdown.

Bar Coding

The computer industry revolution and proliferation of bar coding has streamlined the inventory process in all sectors of the economy. Many retailers now use automatic scanning computer registers to record sales and track inventory immediately. These innovations have had the spillover effect of providing almost instant marketing information regarding the rate of sale or use of products. The increased use of bar code scanning and more sophisticated electronic systems

² The recent earthquake in Kobe, Japan, emphasized the potential disadvantage which this system produces, when many Japanese manufacturers, who were otherwise unaffected, had to shut down because of interruptions to suppliers and transportation.

Table 2

Inventory-to-Sales Ratio (January 1970 - December 1994)

Stage of Processing	Mean	Maximum	Minimum	Dec. 1994
Finished Goods				
Motor vehicles	0.147	0.261	0.099	0.115
Primary metals	0.635	1.032	0.372	0.545
Electrical	0.564	0.709	0.481	0.511
Non-Electrical	0.664	0.972	0.442	0.452
Work-in-Process				
Motor vehicles	0.298	0.730	0.137	0.139
Primary metals	0.862	1.338	0.564	0.677
Electrical	0.960	1.174	0.676	0.689
Non-Electrical	0.878	1.123	0.614	0.614
Materials & Supplies				
Motor vehicles	0.366	0.762	0.185	0.185
Primary metals	0.863	1.365	0.567	0.605
Electrical	0.679	0.893	0.541	0.554
Non-Electrical	0.647	0.886	0.437	0.514

over the last 10 years has led to more efficient retail (and wholesale) inventory management. This increased efficiency has not necessarily manifested itself as lower inventory levels, but allows more precise selection of stock items. In the retail sector, the inventory-to-sales ratio has actually increased slightly in contrast to the aggregate. The reasons for this increase are not obvious, but retailers must keep visible inventory on hand to stimulate sales, and therefore have less flexibility in inventory levels. In addition, an increase in the total number of stores³ may have also contributed to the increase in aggregate retail inventory.

There have been efforts at limiting inventories at the retail level. "Quick Response" is the retail equivalent to JIT. Some retailers try to limit inventory by streamlining customer orders. The effectiveness of these efforts has been limited and so far appears to have had little impact on the level of aggregate retail inventory relative to sales.

Little (1992) uses quarterly manufacturing and trade data from 1968 through 1990 to test for structural changes in inventory management. Results of regressions of the data divided into two sub-periods (1968:1 to 1982:3 and 1982:4 to

1990:4) support the notion that inventory management methods changed significantly beginning in the '80s. Similar work by Bechter and Stanley (1993) detects changes in the speed of adjustment and desired inventory-to-sales ratio after 1981 in a buffer-stock model.

The evidence supports the assertion that inventory innovations have impacted not only the quantity but also the quality of inventories held by allowing firms to more closely match patterns of use. Manufacturing has been more successful in reducing the quantity of inventory relative to sales, but the innovations in the wholesale and retail sectors should also limit the accumulation of unplanned inventory through more direct feedback of marketing information. As a result, the innovations in all three sectors should tend to limit the error portion of inventory accumulation.

IMPACT OF INNOVATIONS ON THE BUSINESS CYCLE

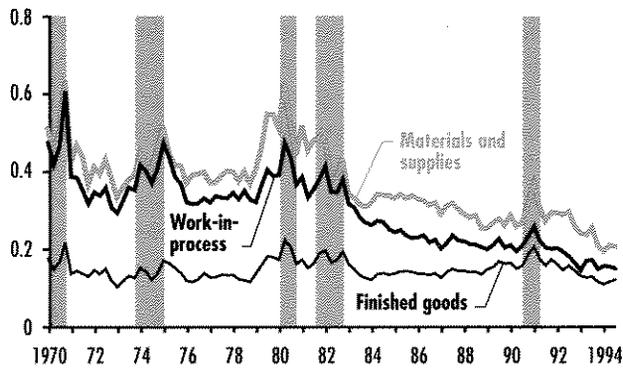
Inventory influences business cycle contractions primarily through unintended increases.⁴ How do the structural shifts in inventory management affect unintended

³ *The Economist* (March 4, 1995) reported in its retail survey that 1993 total shopping center space in the United States was 18.5 square feet per head, compared with 13.1 square feet per head in 1980, according to the Schroder Real Estate Associates.

⁴ Some analysts suggest that higher-than-average growth during the recovery part of the cycle reflects planned inventory investment in anticipation of increased demand.

Figure 4

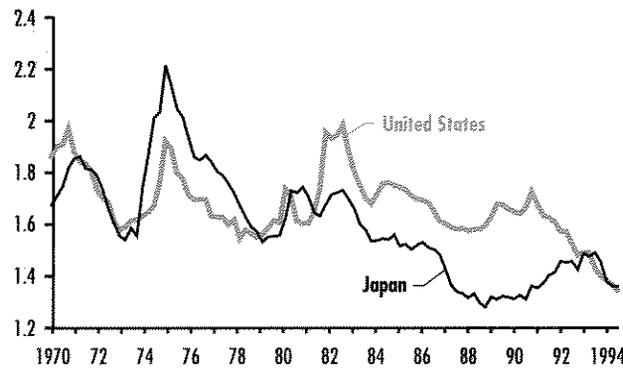
Motor Vehicles Inventory-to-Sales Ratio by Stage of Processing



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis.

Figure 5

Nominal Inventory-to-Sales Ratios for Japan and the United States



SOURCES: U.S. Department of Commerce (Bureau of Economic Analysis) and The Bank of Japan.

inventory build-up? Morgan (1991) suggests that a move to JIT produces a faster reaction to sales shocks and therefore will not result in the levels of unplanned accumulation previously observed. He also argues that as the use of JIT increases, the impact will be to lessen the inventory swings during recessions. Others have tried to directly assess the impact on the business cycle. Little (1992), for example, focuses on the transitory nature of the changes and suggests that the ongoing effort to reduce inventories were a drag on the recovery portion of the 1990-91 recession. The expected inventory accumulation after demand

rebounded was offset by the continuing effort to reduce inventory-to-sales ratios. Bechter and Stanley (1993) use estimated parameters from their buffer-stock model to simulate inventory investment and conclude that the new parameters lead to larger inventory swings for a one-time shock in sales. Filardo (1995) uses an atheoretical vector autoregression (VAR) method and a model-based method to test empirically whether the changes in inventory management have muted the business cycle. He concludes there is no evidence of a reduced role for inventory in the business cycle. As Little (1992) suggests, however, the innovations are still being implemented and may not have saturated the market. In this case, there is an insufficient sample size to evaluate the business cycle impact empirically.

It is difficult to separate the effect of those firms using JIT from those which do not. One approach is to see if the industries that have converted to JIT now contribute less inventory investment during the recession. Primary metals, electrical machinery, non-electrical machinery and motor vehicles have shown significant decline in their inventory-to-sales ratios in the last 10-15 years. I looked at the 1980, 1982 and 1990 recessions to determine the contribution of these industries during the quarter with the biggest reduction in inventory. Together, the four industries contributed a net 22 percent to the third quarter 1980 change in business inventory, a net 29 percent to the fourth quarter 1982 change in business inventory, but only net 1.6 percent to the fourth quarter 1990 change in business inventory. The remaining manufacturing industries contributed 33 percent, 19 percent and 36 percent to the change in business inventories during these periods. These four industries that have reduced their inventory-to-sales ratios significantly over the past two decades contributed less to inventory swings in the 1990 recession than in 1980 or 1982. Despite the reduction in contribution by these industries, the change in business inventory contributed a higher proportion to the change in GDP during the 1990-91 downturn than in 1980 or 1981-82, but the magnitude of the decline in GDP was less in

1990-91 than in 1980 or 1981-82. On the surface, it appears that JIT may help reduce the magnitude of the inventory swing.

Another way to test the impact of JIT on business cycles is to compare the Japanese with the U.S. experience. First, we can look for evidence that Japan does maintain lower inventory levels. Figure 5 shows the inventory-to-sales ratio for the Japanese and U.S. manufacturing sectors. The Japanese ratio is lower than the United States during the 1980s, but both ratios have converged as the United States' decreased and Japan's increased somewhat.

Assuming that the lower inventory-to-sales ratio in Japan confirms the higher usage of JIT there, how does Japan's business cycle experience compare with the United States? Unfortunately, an exact comparison is not possible because Japan has not recorded many periods of declining output. Using dates from Japan's Research Bureau Economic Planning Agency,³ Japan's business cycles have had longer contractionary periods in the postwar era, averaging 16 months, compared with 11 months for the United States. Japan recorded 10 business cycles after World War II, compared to the United States' nine. The average duration of Japan's business cycles (50 months) and the expansion periods (33 months) were shorter than the United States' (63 months and 52 months, respectively).

Table 3 shows the changes in Japanese business inventory compared to changes in GDP during its last six contractions. Three of these six contractions had countercyclical inventory movement. Similar data for the United States (Table 1) shows unambiguous procyclical movement in business inventory. The data suggest that inventory changes may play a lesser role in GDP fluctuations in Japan than in the United States. How much of this is attributable to inventory management methods and how much is due to the difference in business cycle definition is uncertain.

Even if the use of JIT inventory management methods can dampen business cycles, this method is most applicable at the manufacturing level. The contribution of manufacturing, wholesale and retail inventories to

Table 3

Changes in Japanese Inventory Investment During Business Cycle Troughs

Recession Period Peak to Trough ¹	Change in Real GDP ²	Change in Inventory Investment ²	Change in Inventory Investment as a Percentage of Change in Real GDP
1970:3 - 1970:4	-158.5	-527.0	332.5
1973:4 - 1974:1	-5296.8	7304.7	-137.9
1977:2 - 1977:3	1417.0	-499.5	-35.3
1980:1 - 1980:2	-453.0	4.3	-0.9
1985:4 - 1986:1	-3319.0	952.2	-28.7
1992:1 - 1993:4	-5097.0	-2807.4	55.1
Mean			30.8

¹ Peaks and trough correspond to peak and trough (or minimum growth) of real GDP during the contractions listed by the Research Bureau of the Economic Planning Agency of Japan, but do not always coincide with the peak and trough of the period.

² Billions of 1985 Yen (SAAR).

total trade inventories has been changing over the last two-and-a-half decades. More recently, manufacturing's share has declined from 56.8 percent to 43.8 percent. Retail inventories have increased from a share of 24.3 percent to 31 percent. Wholesale inventories' share of the total has increased from 18.9 percent to 25.2 percent. The increased retail inventory-to-sales ratio and a greater retail share of the aggregate inventory may offset the gains in dampening the cycle from JIT at the manufacturing level.

CONCLUSION

The data support anecdotal evidence that inventory management methods in the United States have changed significantly over the past decade or two. The result of these changes is evident in the reduced business inventory-to-sales ratio, driven almost entirely by lower inventories of work-in-process, and materials and supplies rather than finished goods. The impact

³ The Japanese agency uses the Lucas (1977) definition, which loosely defines the business cycle in terms of deviation from trend growth. For most of the contractionary periods listed, Japan's GDP grew less than trend but did not experience a decline.

of these changes in inventory management techniques on business cycles is ambiguous. All other things being equal, inventory management innovations should reduce the probability of unintended accumulation. But as long as firms overestimate or underestimate future demand, inventory cycles will persist. And if cutbacks in production are required to reduce inventory, then the resulting reduction in income could result in lower demand and further inventory buildup. Inventory management innovations are not a panacea for taming business cycles, but in the long run these innovations can contribute to a faster response of production to changes in demand, which in turn can reduce the boom-bust cycle in the economy.

REFERENCES

- Bechter, Dan M., and Stephen Stanley. "Economic Stability in the 1990s: The Implications of Improved Inventory Control," *Business Economics* (January 1993), pp. 35-8.
- _____. "Evidence of Improved Inventory Control," Federal Reserve Bank of Richmond Economic Review (January/February 1992), pp. 3-12.
- Blinder, Alan S. *Inventory Theory and Consumer Behavior*. University of Michigan Press, 1990.
- _____. and Louis J. Maccini. "The Resurgence of Inventory Research: What Have We Learned?" *Journal of Economic Surveys* (No. 4, 1991), pp. 291-328.
- Filardo, Andrew J. "Recent Evidence on the Muted Inventory Cycle," Federal Reserve Bank of Kansas City Economic Review (second quarter 1995), pp. 27-43.
- Holt, Charles C., Franco Modigliani, John F. Muth and Herbert A. Simon. *Planning Production, Inventories, and Work Force*. Prentice-Hall, Inc., 1960.
- Larson, Paul D. "Transportation Deregulation, JIT, and Inventory Levels," *The Logistics and Transportation Review* (June 1991), pp. 99-112.
- Little, Jane Sneddon. "Changes in Inventory Management: Implications for the U.S. Recovery," Federal Reserve Bank of Boston *New England Economic Review* (November/December 1992), pp. 37-65.
- Lucas, Robert E., Jr. "Understanding Business Cycles," in Karl Brunner and Allan H. Meltzer, eds., *Stabilization of the Domestic and International Economy*. Carnegie Rochester Conference Series, vol. 5. North-Holland, 1977.
- Metzler, Lloyd A. "The Nature and Stability of Inventory Cycles," *Review of Economic Statistics* (February 1941), pp. 113-29.
- Morgan, Donald P. "Will Just-In-Time Inventory Techniques Dampen Recessions?" Federal Reserve Bank of Kansas City *Economic Review* (March/April 1991), pp. 21-33.
- Olney, Martha L. "Credit as a Production-Smoothing Device: The Case of Automobiles, 1913-1938," *The Journal of Economic History* (June 1989), pp. 377-91.
- "Retailing" Survey, *The Economist* (March 4, 1995), pp. 3-18.
- Scarf, Herbert E. "The Optimality of (S,s) Policies in the Dynamic Inventory Problem," in Kenneth J. Arrow, Samuel Karlin and Patrick Suppes, eds., *Mathematical Methods in the Social Sciences*, 1959. Stanford University Press, 1960, pp. 196-202.