Recent Evidence on the Muted Inventory Cycle

By Andrew J. Filardo

Inventories play an important role in business cycles. Inventory build-ups add momentum to the economy during expansions, while inventory liquidations sap economic strength during recessions. In addition, because inventory fluctuations are notoriously difficult to predict, they present considerable uncertainty in assessing the economic outlook.

The role of inventories in shaping the current outlook for the U.S. economy is particularly uncertain. In the early 1990s, inventory swings appeared less pronounced than usual, leading some analysts to conclude the business cycle might now be more muted. New inventory control practices, they believed, were permanently diminishing the role of inventories in the business cycle. Yet, recent strong inventory restocking suggests this conclusion might be premature. Inventories may be just as important in the business cycle today as in the past.

This article examines recent inventory data to assess whether the role of inventories in the business cycle has changed. The first section reviews the argument that new inventory control practices have muted swings in inventories. The second section uses data from the current expansion to update estimates of the empirical relationship between inventories and the business cycle. The article finds little evidence to suggest inventories are playing a reduced role in the business cycle, and therefore rejects the view that a change in inventory behavior has muted the business cycle.

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IMPROVED INVENTORY CONTROL AND THE MUTED INVENTORY CYCLE

During the last two decades, many firms have successfully adopted new inventory control practices. By modifying the way they manage their inventories, firms have lowered costs and strengthened their balance sheets. The widespread adjustments made at the firm level have raised the possibility that inventory behavior throughout the economy has also changed, thereby altering the business cycle.[1]

Tighter control produces leaner inventories

Many businesses have been able to reduce costs by holding leaner inventories. The cost savings arise from tighter control of the flow of inputs into the production line. Tighter control enables firms to produce without disruption because the firm receives smaller but more frequent supply deliveries. Such a practice helps firms reduce their level of inventories for any level of production.[2]

To understand how more frequent deliveries of supplies can reduce inventory levels, imagine an auto assembly line designed to produce 200 cars each month. Under the old inventory system, the carmaker might receive a delivery of 200 chassis on the first of each month. At the end of the first production week, the accountant's ledger would show 50 cars produced and 150 chassis remaining in the stockroom as inventory. At the end of the second week, the ledger would show 50 cars and 100 chassis, and so on. Thus, at the end of the month, the accountant's ledger would show the plant had produced 200 cars, with a weekly average of 100 chassis in inventory.

Under a more tightly controlled inventory system, the carmaker could reduce stockroom supplies by receiving chassis deliveries on a more timely basis. For example, if delivered weekly, the chassis inventory would begin each week at 50. Working the inventory down to zero during the week, the firm would reduce its weekly average inventory holdings to 25. Thus, the new inventory control practices would help the carmaker cut its weekly average level of inventories from 100 to 25 chassis.

By fostering leaner inventories, the new inventory control practices produce both direct and indirect benefits to the firm. Direct benefits stem from lower costs of production. For example, a firm can cut interest costs because it can finance leaner inventories, and the firm may cut rental costs by requiring less warehouse space. Indirect benefits arise from the production flexibility that is inherent in the new practices. Firms using the new practices closely monitor production line flows, making it easier to catch potential production bottlenecks and shortages and to adjust supplies more quickly.[3]

Initial support for the muted business cycle view

Evidence from the early 1990s hinted that widespread adoption of new inventory control practices might be influencing aggregate business activity by altering the aggregate inventory cycle. The aggregate inventory cycle is made up of swings in inventory investment, or the change in the stock of inventories from one period to the next. By moderating the amplitude of the inventory cycle, and by shifting its timing, the new practices might modify aggregate inventory behavior and thus mute the business cycle.

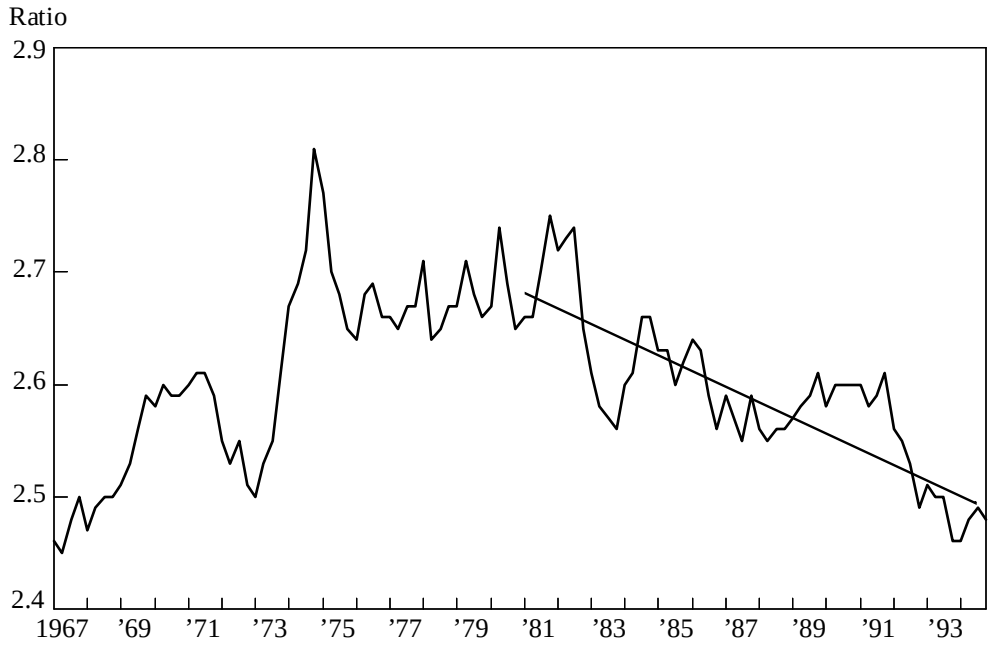
Reducing the amplitude of the inventory cycle. Improved inventory control practices might reduce the amplitude of the inventory cycle in two ways. The first way is by reducing inventories relative to sales. If a sufficient number of firms adopted the new practices, the economywide inventory-to-sales ratio would be likely to fall.[4] As a result, swings in aggregate inventory investment would become more muted. For example, in the old system, with an inventory-to-sales ratio of 2, a $100 increase in sales would be matched by a $200 increase in inventories. If inventory investment had previously been zero, then inventory investment would increase by $200. With the new inventory control practices, the inventory-to-sales ratio might fall to 1.5. In this case, a $100 increase in sales would be matched by a $150 increase in inventory investment. As a result, the new inventory controls would cause swings in the inventory cycle to be muted.

A muted inventory cycle would reduce swings in economywide production, or gross domestic product (GDP). GDP, which comprises final sales and inventory investment, is a measure of aggregate production of final goods and services during a certain period. In the old system, production is increased by the extra $100 in sales and $200 in inventory investment. Consequently, GDP increases by $300.[5] In the new system, GDP only increases by $250. Thus, the new inventory control practices would not only mute the inventory cycle but also the business cycle.

Several studies in the early 1990s pointed to downward trends in inventory-to-sales ratios as evidence that the inventory cycle was fundamentally changing (Morgan; Strongin; Little). For example, the nonfarm inventory-to-sales ratio from

Chart 1

Nonfarm Inventory-to-Sales Ratio



Source: Bureau of Economic Analysis.

the National Income and Product Accounts (NIPA) fell from 2.74 in 1980 to 2.58 in 1990, a decline of 6 percent (Chart 1). Furthermore, the timing of the ratios' downward trend coincided with the widespread adoption of the new inventory controls.[6]

A second way the new practices might moderate the amplitude of the aggregate inventory cycle is by softening the impact of unexpected changes in demand. Under the old system, a carmaker may receive a monthly delivery of 50 chassis and then discover that demand had increased by an additional 40 cars a month from that time onward. Without the extra inventories, the carmaker could not meet the extra 40-car demand until the following month. Then, faced with 40 back-ordered cars and an extra 40-car demand for the new month, the carmaker would increase its inventory order from 200 to 280 chassis at the start of the new month.

In contrast, the new inventory controls permit smaller adjustments to inventories. Firms are better able to respond to changes in demand because they receive more frequent deliveries matched more closely to production needs. The carmaker can begin adjusting inventories and production levels next week rather than next month. He can boost the chassis order by 20 at the end of the first week (ten for the new demand and ten for the backorders) and by ten chassis for each following week. Over the course of the month, the new inventory controls lead to an inventory adjustment of 50 rather than 80 chassis. In this way, flexibility in reacting to changing demand might reduce the amplitude of the inventory cycle.

Shifting the timing of the inventory cycle. New

inventory control practices might also help mute the business cycle by shifting the timing of the inventory cycle relative to final sales. Traditionally, swings in inventory investment and final sales have tended to move together. Thus, inventory swings have magnified final sales swings, producing larger swings in economic activity than otherwise. But, if the timing of the cycles were to change—for example, if inventory investment were to swing downward as final sales swung upward—the business cycle would become more muted.

The extra flexibility provided by the new inventory control practices might alter the timing of the cycles. The new practices encourage firms to more freely build up and liquidate inventories. In the face of temporary peaks in demand, firms are more likely to liquidate inventories because they can more easily build them up again in the future. If the temporary increase is larger than expected or part of it turns out to be permanent, the new flexibility reduces the risk that firms will be caught holding too few inventories. Thus, with firms more likely to liquidate or accumulate inventories when demand changes, the inventory and final sales cycles will move together less closely, thereby muting the business cycle.

Recognizing that new inventory control practices might lead to changes in both the amplitude and timing of the inventory cycle, it is not hard to see why some analysts supported the muted business cycle view in the early 1990s. But, until recently, there simply has not been enough data to prove or disprove the view.

RECENT EMPIRICAL RECORD FOR INVENTORY INVESTMENT AND BUSINESS CYCLES

New and revised data give researchers an opportunity to reexamine the links between new inventory practices, aggregate inventory behavior, and the business cycle.[7] This section analyzes both broad trends and regression evidence to determine whether the new inventory control practices have had a perceptible effect on the aggregate economy.[8]

Broad trends

Analyzing broad trends in the data can identify the more easily recognizable relationships between inventory investment and the business cycle. If the new inventory control practices had significantly changed the behavior of aggregate inventories and thus business cycles, such changes should be apparent in the data on inventories.

Three broad trends in the data are examined: sectoral inventory-to-sales ratios, the direct contribution of inventories to GDP, and the behavior of inventory investment in various phases of the business cycle. Special attention is paid to the recent business cycle recession of 1990-91 and the first three and one-half years of the current expansion. Even though subtle relationships may be missed in such an analysis, these broad trends cast serious doubt on the muted business cycle view.

Sectoral inventory-to-sales ratios. As suggested earlier, the muted business cycle view garnered support in the early 1990s mainly because the NIPA nonfarm inventory-to-sales ratio appeared to trend downward during the 1980s and early 1990s. Some analysts interpreted this trend to indicate that inventory holdings were becoming leaner. Other measures of inventories and sales, however, suggest the trend in the nonfarm ratio may be misleading.

One measure that does not corroborate a long-term trend toward leaner inventory holdings is the MTIS manufacturing and trade inventory-to-sales ratio. MTIS data come from the Census Bureau's Survey of Manufacturing and Trade Inventories and Sales. In contrast to the long-term downward trend found in the NIPA nonfarm inventory-to-sales ratio, the MTIS manufacturing and trade inventory-to-sales ratio trended upward throughout much of the 1980s. Only since 1990 have manufacturing and trade inventories declined relative to sales (Chart 2).

The apparent contradiction between the MTIS

Chart 2

Manufacturing & Trade Inventory-to-Sales Ratio

Source: Census Bureau.

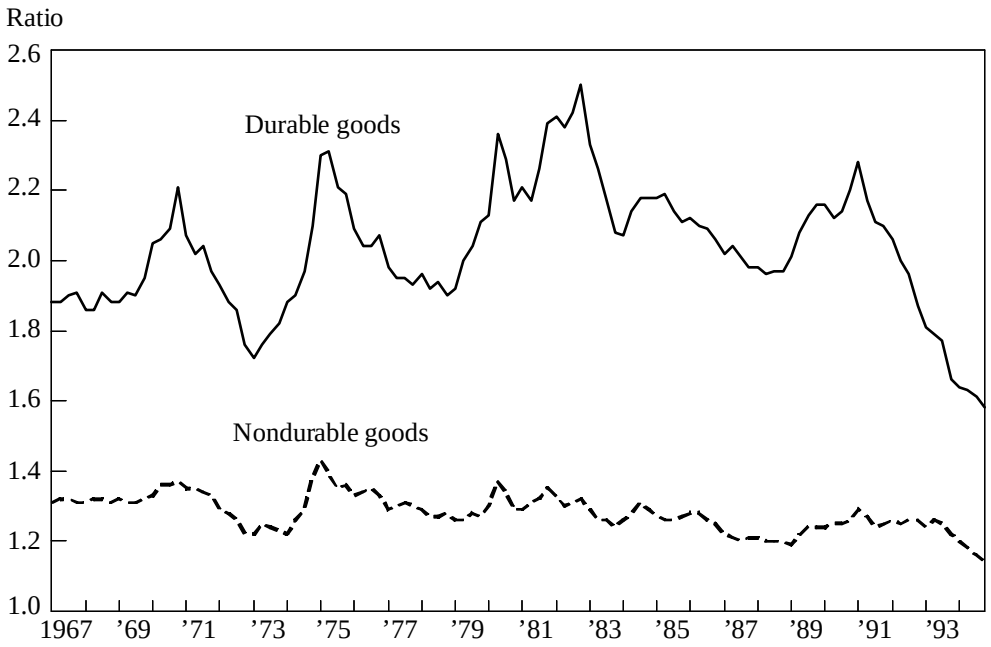
and NIPA data reflects a difference in the way the statistics are measured. The MTIS inventory data come from surveys of the same firms that provide sales data. The NIPA inventory and sales data are not as comparable. Although 90 percent of the NIPA inventories are from MTIS inventory data, NIPA final sales data are substantially different from MTIS sales data.[9] As a result, MTIS data produce a better measure of the inventory-to-sales ratio than NIPA data.

Splitting the broad MTIS inventory-to-sales ratios into manufacturing and trade further weakens the case that the decline in the nonfarm inventory-to-sales ratio is due to new inventory control practices.[10] Manufacturers were the primary users of the new inventory controls in the 1980s and 1990s (Freeland). According to the muted business cycle view, the inventory-to-sales ratio for manufacturers should have trended down dramatically as new inventory control practices became more widespread. Yet, inventories of manufacturing firms, which account for about 35 percent of aggregate inventories, dropped only slightly during the 1980s (Chart 2). Furthermore, inventories for retail and wholesale trade, which account for the bulk of inventories, actually rose slightly.

Scrutiny of the manufacturing data reveals that durables manufacturing industries bore the brunt of the decline in the manufacturing inventory-to-sales ratio during the 1980s and 1990s. The nondurables manufacturing ratio has actually remained relatively flat since the new inventory control practices were introduced (Chart 3).[11] Taken together, these results indicate that changes in durables manufacturing

Chart 3

Durable and Nondurable Goods Inventory-to-Sales Ratio



Source: Census Bureau.

would have to account for the bulk of the change in aggregate inventory behavior if the muted business cycle view were correct. Yet, this segment of the economy accounts for only 11 percent of the nation's output and 23 percent of aggregate inventories.[12] This segment is much too small to have caused aggregate inventory behavior to fundamentally change.

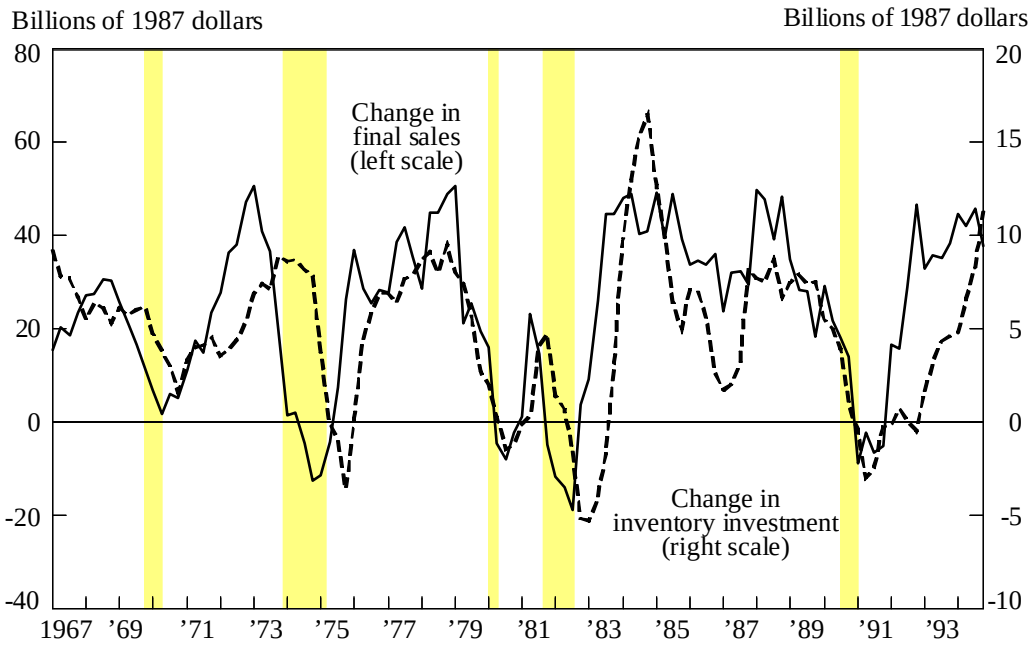
Inventory investment. Inventory investment is another, more informative measure of aggregate inventory behavior than the inventory-to-sales ratio. While the inventory-to-sales ratio may reliably measure the leanness of inventories, the ratio may not always reflect cyclical economic activity. For example, when inventories move lockstep with sales, the inventory-to-sales ratio may remain flat despite rapid expansions or severe recessions.[13] If in an expansion both inventories and sales increased 20 percent, the inventory-to-sales ratio would not change. But inventory investment would nevertheless contribute to the increase in output.

By contrast, inventory investment more accurately reflects the role of inventories in the business cycle. Because real GDP equals real final sales plus inventory investment, swings in inventory investment potentially reveal more information about the business cycle than can be revealed by swings in the inventory-to-sales ratio.

Under the muted business cycle view, new inventory control practices should have reduced the swings in inventory investment. Recent data, however, show that inventory investment swings have not become more muted. Since the new inventory control practices were introduced, average changes

Chart 4

Inventory Investment and Final Sales



Note: Data are the change in the four-quarter moving averages.
Source: Bureau of Economic Analysis.

in inventory investment have actually increased rather than decreased. A simple statistical measure of these swings is the standard deviation of aggregate inventory investment. From 1970 to 1980, the standard deviation of aggregate inventory investment from its mean was 18. From 1980 to the fourth quarter of 1994, the standard deviation was 26.[14] This latter number represents a statistically significantly increase in the volatility of inventory investment.

Further evidence against the muted business cycle view comes from examining the relationship between aggregate inventory investment and final sales. If the business cycle were muted, the historical association between inventory investment and final sales data would have weakened during the 1980s. In particular, the change in inventory investment and the change in final sales would not have moved together as closely as in the past or might have started to trend apart.

The systematic variation of inventory investment with final sales, however, shows no clear break or gradual drifting apart of trends since the mid-1970s (Chart 4). Indeed, when final sales rise and fall, inventory investment follows with a slight lag. This timing pattern is particularly clear for the recovery periods in the mid-1970s, the early 1980s, and now in the 1990s. In short, swings in final sales and inventory investment trended neither upward nor downward in the 1980s or now in the 1990s. Moreover, the size and timing of the swings have not been significantly different than in the past.[15]

Inventory investment during expansions and recessions. While inventory investment swings clearly affect economywide activity, these swings have traditionally played an even bigger role during certain periods of the business cycle. During recessions and certain years in expansions, inventory investment fluctuations dominate economic activity. Consequently, by examining these periods more closely, changes in inventory behavior due to the new inventory control practices may appear more pronounced.

Swings in inventory investment can account for the bulk of short-term swings in the economy, especially during recessions. Since 1947, inventory investment has averaged about $15 billion per year, about one-half of 1 percent of real GDP. Nevertheless, declines in inventory investment have made up the lion's share of the drop in real GDP during recessions. In fact, inventory investment has accounted for about 54 percent on average of the drop in economic activity during recessions (Table 1). And, in some recessions, inventory investment has contributed more to the decline in GDP than either consumption, fixed investment, government spending, or net exports. This dominant behavior has led some analysts to argue that "business cycles are inventory cycles."[16]

The overall contribution of inventory investment is less dramatic in expansions than in recessions (Table 1). Still, inventory investment can increase substantially during short periods within expansions. For example, during three-quarter periods in each postwar expansion, inventory investment contributed 32 percent, on average, to the increase in real GDP.[17]

In the most recent business cycle, swings in inventory investment seem to be playing their traditional role. In the 1990-91 recession, declining inventory investment contributed 59 percent to the drop in real GDP, similar to the postwar average. In the current expansion, which is almost four years old, inventory restocking has only recently shown significant strength. Over the first three quarters of 1994, inventory investment accounted for 31 percent of GDP growth, similar to the postwar average. In summary, recent broad trends in inventory behavior provide little evidence to support the muted business cycle view. The decline in the nonfarm inventory-to-sales ratio does not appear to be caused by the new inventory control practices. Furthermore, aggregate inventory investment still seems to influence general activity in its traditional way, especially during recessions and certain periods of expansions. Next, this evidence is bolstered by using rigorous statistical methods.

Regression evidence

Two methods can be used to measure links between inventory investment and the business cycle—atheoretical regression methods and model-based regression methods (appendix). These methods not only measure the links between inventory investment and economic activity but also statistically test whether the links have changed. If changed, then key regression parameters would change or the forecasting accuracy of the regressions would deteriorate. Results from these two methods corroborate the broad trends against the muted business cycle already discussed.

Atheoretical method. The first method is an atheoretical regression analysis, technically referred to as a vector autoregression (VAR). Huh used this technique to examine links between inventory investment and GDP in the 1980s. In this method, the growth rate of GDP and the change in inventory investment are modeled as separate equations in a VAR. Other equations and variables are included to capture the various macroeconomic costs of holding inventories.[18] Huh estimated such a VAR from 1959 to 1989 to determine whether the forecast performance of the VAR had significantly declined—a telltale sign that the links had changed. Huh found no significant change in the links during this period. Data through only 1989, however, may prove insufficient to signal a change in inventory behavior.

Table 1

Contributions of Inventory Investment to Business Cycles

Recession peak to trough	Change in real GDP (billion 1987 dollars)	Change in real inventory investment (billion 1987 dollars)	Change in real inventory investment as % of change in real GDP
48:4 - 49:4	-15	-28	195
53:2 - 54:2	-37	-20	54
57:3 - 58:1	-61	-21	35
60:1 - 60:4	-16	-46	288
69:3 - 70:2	-25	-20	79
73:4 - 75:1	-135	-85	63
80:1 - 80:2	-98	-11	11
81:3 - 82:3	-110	-35	32
90:2 - 91:1	-75	-45	59
Average	-64	-34	54

Isolated 3 quarter periods in each postwar expansion*	Change in real GDP (billion 1987 dollars)	Change in real inventory investment (billion 1987 dollars)	Change in real inventory investment as % of change in real GDP
50:1 - 50:4	133.6	38.6	29
54:3 - 55:2	80.9	23.4	29
58:3 - 59:2	96.6	21.3	22
68:4 - 69:3	62.8	16.1	26
73:1 - 73:4	35.8	25.4	71
75:2 - 76:1	166.3	57.5	35
80:2 - 81:3**			
83:2 - 84:1	203.0	70.0	34
93:4 - 94:3***	149.0	46.3	31
Average	116	37	32

* This is not a trough to peak calculation and excludes the recovery phase of the expansion.

** Expansion was too short to perform a meaningful calculation.

*** Peak not yet reached.

Huh's study, therefore, is updated to include five more years of data. Using these data, three tests were run to search for a change in the link between inventory investment and aggregate output. One test measured stability of the regression parameters, another measured stability of the response of inventory investment and aggregate output to unforeseen changes in economic activity, and a third measured forecast accuracy. All three tests failed to reveal such a change. A description of the tests and results is provided in the Appendix. Given these test results, the data provide no evidence of a change in the relationship between inventories and output.

Model-based method. The second method to test whether new inventory practices have muted the business cycle is based on an economic model, such as the one developed by Bechter and Stanley (1992). This method may help explain why a decrease in the aggregate inventory-to-sales ratio may be consistent with an unchanged inventory cycle.

Based on a standard theory of inventory investment, the Bechter and Stanley model of inventory investment has two essential features. First, inventory investment is modeled as a function of the level of current sales, past inventory stocks, and the change in sales. Second, the model incorporates two key parameters. One parameter can be interpreted as a desired inventory-to-sales ratio for a firm. Another parameter measures the speed at which firms adjust actual inventories to their desired level. In this model, new inventory control practices could reduce the target inventory-to-sales ratio, increase the speed of adjustment, or both. The relative magnitude of the changes determines the overall effect on inventory investment.

Examining sectoral inventory investment data, Bechter and Stanley found little evidence the variability of inventory investment shrank during the 1980s. Reductions in the inventory-to-sales ratio were largely matched by increases in the speed of adjustment of inventory levels to desired levels. This finding helps explain why the new inventory control practices at the firm level have not translated into a more muted aggregate inventory cycle. While the desired inventory-to-sales ratio has declined in certain industries, the speed at which firms adjust to new economic conditions has increased.

More recent and revised data confirm Bechter and Stanley's view that the new inventory control practices have not substantially influenced the inventory cycle. In the 1990s, the aggregate and sectoral desired inventory-to-sales ratio and speed of adjustment have not changed as predicted by the muted business cycle view. The trade inventory-to-sales ratio has increased and the manufacturing speed of adjustment has fallen. A description of these results is provided in the appendix. Such evidence strengthens the view that the aggregate inventory component of the business cycle has not become muted.

CONCLUSIONS

The introduction of new inventory control practices in the 1980s suggested that the new inventory behavior might mute cyclical swings in business activity. Analysts who predicted this change pointed to emerging trends in the inventory-to-sales ratio as confirmatory signs.

The recent empirical record, however, fails to support such a view. Inventory-to-sales ratios remain within their historical ranges, and swings in inventory investment continue to follow the regular pattern established over the postwar period. Moreover, statistical tests fail to reveal a structural change in the relationship between inventory investment and aggregate business activity. Thus, despite the adoption of new inventory control practices, concerns that inventory and business cycles are becoming more muted have been exaggerated.

APPENDIX

This appendix describes the atheoretical and model-based methods used in this article to test for structural change in the behavior of aggregate inventories and the business cycle. The tests will highlight the statistical significance of the article's findings.

Atheoretical method

The atheoretical method uses a four-equation system of equations. The system incorporates four variables: the growth rate of output, the six-month commercial paper rate, the growth rate of the CPI-U, and nonfarm inventory investment. The dependent variables of the system of equations correspond to the contemporaneous value of each of these variables. The explanatory variables include lags of each of the dependent variables (and a constant). The appropriate lag length for each equation was chosen by a number of statistical criteria. Specifically, the Akaike Information and Schwartz criteria were used to choose the appropriate lag length. Estimation was performed using ordinary least squares on each equation.

Even though this method is statistically atheoretical—that is, economic theory is not employed to restrict the values of certain parameters—the choice of the variables in the system of equations is motivated by economic theory. In particular, inventory investment is specified as being related to the growth rate of sales and prices. Output growth, inflation, and interest rates are empirical proxies for sales and prices. The output variable plays the role as a proxy for sales because fluctuations in sales are largely associated with fluctuations in output. Fluctuations in inflation and interest rates affect the prices that firms face. Increases in inflation increase the value of holding real goods like inventories, and a reduction in the interest rate reduces the carrying cost of inventories. Thus, inventory investment would tend to rise when the interest rate falls.

Both quarterly and monthly data were used to estimate the atheoretical regression. For the quarterly data, the output growth rate is the logarithmic first difference of real gross domestic product. The other variables are quarterly averages of the monthly data. For the monthly data, the output growth rate is the logarithmic first difference of total industrial production.

If new inventory practices had fundamentally changed the relationship of aggregate inventory holding behavior to output and prices, estimation of the atheoretical regression would exhibit a structural change in the estimated parameters of the estimated equations. Three tests to detect such a change were employed: Hansen's test of parameter stability, a dynamic simulation test, and Lütkepohl's prediction test.

Hansen's test looks at general parameter instability. If new inventory control practices have had a significant aggregate effect, the Hansen test statistic would reject the test of parameter stability for the output equation. In the period from 1959 to the beginning of 1994, the results of the quarterly and monthly regressions are quite stark. With a high degree of confidence (that is, the 5 percent significance level), there is little evidence of parameter instability with these regressions.

The dynamic simulation test examines the

dynamic properties of the multi-equation system. Systems of equations like the atheoretical method have dynamic properties which change if the parameters of the regression change. Moreover, there are two advantages to using this test over the Hansen test. First, an assumption that a break might have occurred in the early 1980s can be easily incorporated. Second, less restrictive assumptions about the data need to be made to run the test. A candidate breakpoint can be chosen by searching over possible breakpoints during the 1980s. The most likely candidate was selected by maximizing the F-statistic of a Chow-type structural breakpoint test (1980:Q4 and 1980:12). Then, similar to Huh's procedure, the regression was estimated from 1959 to the breakpoint and for the full sample. The dynamic properties were compared and found to be statistically indistinguishable.[19] Thus, this test rejects the view there was a structural break in the dynamic properties of the regression in the 1980s.

The Lütkepohl test examines the out-of-sample forecasting performance of the regression. If a structural change in the parameters had occurred, the accuracy of the out-of-sample forecasting performance of the regression would diminish. Using the same breakpoints identified in the previous test, out-of-sample forecasts of various horizons were made. The results show no structural break (using the 5 percent significance level) related to the introduction of the new inventory control practices.

Model-based method

The second method employed to test for structural change is the model-based method of Bechter and Stanley. In their research, Bechter and Stanley specified a standard theoretical model of inventory behavior, called the stock adjustment model. In the model, inventory investment is a function of the level of sales, the change in sales, and the level of inventories. The parameters of the model can be interpreted as the desired inventory-to-sales ratio and the speed of adjustment of the desired inventory level to the actual inventory level.

The estimation of the model differs from Bechter and Stanley's analysis in three ways. First, the data are revised, more aggregated, and run through 1994, as opposed to the first half of 1991 in Bechter and Stanley. The data come from the 1987 benchmark revisions of the NIPA and MTIS data. While Bechter and Stanley looked at disaggregated manufacturing and trade inventories, this article explores aggregate manufacturing inventories, trade inventories, and the two combined. Second, the analysis is extended by considering monthly data. Third, the model is estimated with nonlinear least squares with a correction for first order serial correlation. The constant parameter in the model is constrained to be zero because the means of the stationary variables were removed from the data before estimation. This alternative procedure provided more stable and intuitively plausible parameter estimates than the original Bechter and Stanley procedure.

The alternative regression procedure yields quantitative measures that differ but conclusions that are similar to Bechter and Stanley's conclusions for the 1980s. With quarterly data, ten-year rolling regressions show the desired inventory-to-sales ratio for manufacturing drifted lower in the 1980s.[20] Moreover, declines in the inventory-to-sales ratio were matched by increases in the speed-of-adjustment. Thus, the

quarterly manufacturing data are consistent with Bechter and Stanley's conclusion that a declining inventory-to-sales ratio was offset by a faster speed of adjustment, with no overall effect on the business cycle. In addition, the desired inventory-to-sales ratio for trade trended upward and the speed of adjustment remained statistically flat, which confirm Bechter and Stanley's conclusion that trade did not exhibit behavior consistent with the muted business cycle view.

Quarterly data from the 1990s further weaken the muted business cycle view. According to the view, the speed of adjustment should have risen as the new inventory control practices became more widespread. In the 1990s, however, the speed of adjustment for manufacturing fell precipitously as the desired inventory-to-sales ratio drifted lower. Recent quarterly trade inventories continue to run counter to the muted business cycle view. In particular, the desired inventory-to-sales ratio for trade has grown, while the speed of adjustment has remained roughly flat. The manufacturing and trade desired inventory-to-sales ratio trended upward in the 1980s but has dropped off in the 1990s. The ratio's decline, however, occurred as the speed of adjustment declined.

The monthly data corroborate many of the empirical patterns found with the quarterly data. Subsample regressions highlight the similarity between the monthly and quarterly data.[21] Both samples have similar break points for all three inventory measures (Table A1). For the quarterly data, the estimate of the desired inventory-to-sales ratio for trade rose from 1.39 to 1.48, fell from 1.69 to 1.59 for manufacturing, and changed very little for manufacturing and trade. The monthly results are remarkably similar. The estimated speed of adjustment for the monthly data is smaller than for the quarterly data because monthly inventory investment changes are usually smaller than the quarterly changes.

Monthly five-year rolling regressions for manufacturing and trade inventories confirm the quarterly results and provide more conclusive evidence against the muted business cycle. Monthly data permit the reliable estimation of five-year rolling regressions; five years of quarterly data provide too few data points to stably estimate the model's parameters. The monthly manufacturing data confirm the desired inventory-to-sales ratio's decline in the 1980s, as do the quarterly data. The ratio stopped declining in 1988, however, and has remained constant. The speed of adjustment slowed sharply in the late 1980s and again recently. The flat trend in the inventory-to-sales ratio and the two declines in the speed of adjustment weaken the muted business cycle view because the new inventory control practices were becoming more widespread at the time. Consistent with the quarterly data, the trade inventory-to-sales ratio rose significantly throughout the 1980s and 1990s, while the speed of adjustment remained statistically flat. The manufacturing and trade desired inventory-to-sales ratio fell in the mid-1980s but rose in the late 1980s and has fallen recently. In spite of the declines, the speed of adjustment parameter fell. Thus, the timing of the declines in the inventory-to-sales ratio and the speed of adjustment are inconsistent with the muted business cycle view.

Table A1

Parameter Estimates of the Bechter and Stanley Model

Quarterly results

Sector	Desired inventory-to-sales ratio		Speed of adjustment		R-bar squared	
	Early period	Late period	Early period	Late period	Early period	Late period
Manufacturing and trade	1.53 (.01)	1.54 (.02)	.15 (.02)	.17 (.05)	.56	.44
Manufacturing	1.69 (.01)	1.59 (.09)	.13 (.02)	.08 (.06)	.59	.51
Trade	1.39 (.01)	1.48 (.01)	.28 (.08)	.14 (.06)	.31	.07

Monthly results

Sector	Desired inventory-to-sales ratio		Speed of adjustment		R-bar squared	
	Early period	Late period	Early period	Late period	Early period	Late period
Manufacturing and trade	1.54 (0.01)	1.54 (0.02)	.049 (0.006)	.034 (.01)	.34	.17
Manufacturing	1.69 (.01)	1.53 (.89)	.039 (.004)	.001 (.008)	.38	.23
Trade	1.39 (.01)	1.47 (.01)	.056 (.014)	.054 (.014)	.14	.13

Notes: For the quarterly data the early period for manufacturing and trade is 1967:Q2 to 1983:Q2 for manufacturing is 1967:Q2 to 1983:Q2 for trade is 1967:Q2 to 1983:Q3. The late period runs from the end of the early period to 1994:Q4. For the monthly data, the early period for manufacturing and trade is 1967:2 to 1983:5; for manufacturing it is 1967:2 to 1983:4; for trade it is 1967:2 to 1983:8. The late period runs from the end of the early period to 1994:12.

Source: Author's calculation.

ENDNOTES

[1] As Abramowitz and Stanback found many decades ago, inventory fluctuations are quite important in understanding business cycles. However, economic research still has not provided a simple theoretical explanation of how changes in inventory control techniques will affect the business cycle. Much of the problem stems from the lack of consensus of how firm decisions are linked to economywide activity. Ongoing inventory research continues to grapple with the basic issue of why firms hold inventories (Blinder and Maccini). Historically, the Production Smoothing Model (PSM) has dominated the literature even though the model's most basic predictions are inconsistent with the data. Alternative models include sophisticated cost shock models (Eichenbaum; West), the lumpy inventory delivery models (Blinder; Ramey; Lovell), and the Stockout Avoidance Model (Kahn; Thurlow). The jury, however, is still out on these models.

[2] This article focuses on just-in-time (JIT) inventory management techniques. See Morgan for a discussion of JIT.

[3] Survey evidence confirms that firms using new inventory control practices (mostly manufacturing firms) have reaped significant benefits (Freeland, Norris, and others). Specifically, both inventories and warehouse space are reduced, cutting the average cost of production, and product quality has risen. In addition, firms also reported enhanced control over the flow of inventories in the production line, leading to a more streamlined production process. Freeland and Norris, Swanson, and Chu also find the benefits of JIT techniques have been largely realized at firms that implemented the techniques.

[4] Do leaner inventories at the firm level translate into leaner economywide inventories? If all firms were to implement these techniques, then aggregate inventory levels would fall. However, only a fraction of the firms have employed these new inventory practices. As a result, some firms may have achieved leaner inventory levels by pushing the extra inventories back onto the suppliers. In the automobile manufacturer example, the chassis supplier may simply store the chassis at his warehouse rather than at the storeroom of the auto manufacturer. In that case, the aggregate level of inventories would not change. Survey evidence from suppliers, however, does not support this case. In addition, Morgan finds that suppliers have adapted to these new practices; therefore, mere inventory shifting in the aggregate is not occurring.

[5] GDP can be broken down into sales of final goods and services (S) plus the change in inventories, or inventory investment (II). By definition, $GDP = S + II$. Swings in GDP, therefore, are comprised of swings in final sales and swings in inventory investment. Letting ΔGDP denote the change in GDP from time t to time $t-1$, $\Delta GDP = \Delta S + \Delta II$.

[6] Even though researchers at the time would admit that available data in the early 1990s were inadequate either to accept or to reject conclusively their view, the data lent support to their view that firm-level changes were having economywide effects.

[7] In March 1993, the Census Bureau revised the inventory data from 1988 to January 1993. These changes were undertaken to benchmark to the more accurate sampling results of the 1991 Retail Trade Survey. Such revisions have had a substantial effect on the interpretation of recent trends in inventory behavior (Huh).

[8] Recent evidence has emerged about the limited benefits of the new inventory control practices. In the United States, the strength of the current expansion has led some businesses to reassess the appropriateness of these new inventory control practices (Bleakley). Japan, which has had more experience with new inventory control practices, has seen some limits to the benefits of JIT too (Cusumano). Furthermore, Wilkinson notes that Japanese inventory investment fluctuations account for the same or as much of the volatility in United States and many OECD countries.

[9] Why do the NIPA and MTIS inventory-to-sales ratio differ even though the bulk of the NIPA inventories are made up of MTIS inventories? In other words, why does the NIPA inventory-to-sales ratio decline since the early 1980s while the MTIS ratio does not? The answer may come from the data sources for the inventory and sales data as well as the statistical procedure used to construct the ratios.

The Bureau of Economic Analysis (BEA) starts with the MTIS inventory data to estimate economywide inventories. BEA augments the MTIS with Other Nonfarm Inventories—which include construction materials and supplies, transportation, public utilities, communication, mining, FIRE, and Other. Other Nonfarm accounts for only 9 percent of inventories—a relatively small share.

The economywide final sales data, however, differ significantly from the MTIS sales data. The NIPA final sales data are the final sales from domestic businesses which are final sales of domestic product less gross product of households and institutions and general government and a small amount of final sales by farms. Not only do the NIPA sales data include many firms that do not contribute to the inventory number but also leave out some firms who hold inventories. MTIS sales include some firms that only provide intermediate good sales.

[10] Trade includes both retail and wholesale trade.

[11] To be fair to the proponents of the muted business cycle view, inventory data were revised in 1993. The new data significantly revised the inventory-to-sales ratios upward since 1987. Also see Huh on this point.

[12] Recent surveys of just-in-time (JIT) production processes reveal that JIT has helped to pare inventory levels in certain industries (Norris and others). But other economists have discussed the fact that many industries have not been able to implement JIT techniques and other lean manufacturing techniques.

[13] See Chapter 5 of Blinder for an expanded explanation of why the inventory-to-sales ratio is a poor cyclical indicator.

[14] Standard deviation measures a time series' variability around its mean. A standard deviation of 18 around a mean of about $20 billion from 1970 to 1980 indicates that 90 percent of inventory fluctuations will lie between -$10 billion and $50 billion. A standard deviation of 26 around a mean of about $15 billion from 1980 to 1994 indicates 90 percent of the variability will lie between -$30 billion and $60 billion.

Examining the standard deviation of the growth rate of inventories rather than the standard deviation of inventory investment yields similar results. During the period from the end of the 1980s through 1994, the standard deviation does not significantly decline. Other breakpoints during the 1980s reveal similar results about the decline in the standard deviation of inventory investment.

[15] In the current expansion, the lag of the change in inventory investment to the change in final sales can be accounted for by weakness of overall business activity which has led many businesses to be more cautious about inventory investment.

[16] See Blinder and Holtz-Eakin.

[17] The postwar expansion's average contribution of the change in inventory investment to changes is GDP is roughly 15 percent.

[18] The standard measure of the costs is the real interest rate. Rather than using a measure of the real interest rate, the nominal interest rate (ten-year Treasury bond rate) and the inflation rate (CPI) are modeled as two separate equations in the system.

[19] The dynamic properties are captured by standard impulse responses with their bootstrap two standard error bands.

[20] Charts showing the results from these rolling regressions are available from the author.

[21] The date to split the data into two subsamples was found statistically. For each possible date, one regression was run on the data before the date and one after. The date at which the parameters of the model changed the most across the samples was chosen as the date to split data into subsamples. Changes in the parameters of the model across the subsamples were measured with a standard F-test.

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