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Has Inventory Volatility Returned? A Look at the Current Cycle

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The massive liquidation of inventories during the 2001 recession contrasts sharply with the more moderate inventory movements observed in recent decades. While the rundown might be seen as evidence that firms are not managing their inventories as effectively as some economists have claimed, a careful analysis of inventory behavior in 2001 suggests that during much of the recession, firms were successfully regulating their inventories to avoid a large buildup of excess stock.

Throughout the recession that began in March 2001, U.S. firms sold off inventories at an extraordinarily rapid pace. During the first three quarters of 2001, inventories dropped by \$120 billion.¹ The liquidation then accelerated sharply, reaching a stunning rate of \$114 billion in the fourth quarter alone. The sell-off of inventories in this brief three-month period represented 3.1 percent of goods sector output and was, by this measure, the largest in more than fifty years.

The rundown is all the more remarkable in that large changes in inventories have become relatively rare in recent decades. Quarterly changes exceeding 2 percent of goods sector output occurred 43 percent of the time during the 1953-83 period but only 24 percent of the time since 1984.

The 2001 liquidation is difficult to square not only with the smoother inventory behavior since 1984, but also with the explanations of this behavior put forward by a number of economists in recent years. These economists attribute the moderation in inventory movements in the last two decades to firms' improved ability to manage their inventories. In this view, technological advances have helped firms to anticipate changes in demand and thus to avoid abrupt changes in production and inventories. An important corollary to this argument is that better inventory management may have lowered business cycle volatility by reducing the role played by inventory swings.²

In this edition of *Current Issues*, we investigate the apparent conflict between the huge inventory liquidation of the 2001 recession and the inventory trends discerned by economists. Does the sharp rundown in inventories mean that firms have *not* substantially improved their control of inventories? And is the steep plunge in the fourth quarter evidence that inventories may continue to exacerbate business cycle fluctuations?

To resolve these questions, we undertake a detailed comparison of the behavior of inventories in the 2001 recession and in previous recessions. Significantly, we find that firms were, in fact, exercising better inventory control in the first three quarters of 2001. Unlike businesses in recessions prior to 1984, firms anticipated the slowdown in sales well before the recession began and were shedding inventories from the outset in a calculated effort to avoid a heavy buildup of stocks. The fourth-quarter liquidation, however, was in all likelihood unintentional—the result of underestimating future sales growth during a period of great uncertainty.

We also argue that the error in forecasting sales growth in the fourth quarter has helped set the stage for economic recovery, since the resulting shortfall in inventories will require businesses to boost production aggressively to replenish their stocks. A simulation exercise suggests that even a partial correction in the supply of inventories could add more than 1 percentage point to GDP growth in 2002.

Inventory Management and the Business Cycle: Some Background

Economists have long suggested that inventories ought to play a “buffer stock” role, insulating production from the volatility of sales. According to this notion, producers would refrain from adjusting output to match each large shift in sales. Instead, they would use their inventories to absorb sales fluctuations, allowing stocks to run down during periods of strong sales and to accumulate when sales were slow. By adopting this strategy, producers could maintain a relatively smooth stream of output—typically a more efficient mode of production than making frequent changes to output.

In practice, however, producers have generally chosen to move their inventories *in the same direction* as sales. Indeed, evidence suggests that firms target a relatively fixed ratio of inventory to sales, with the result that a rise in sales causes firms to adjust their stocks upward while a decline in sales prompts them to cut back on their stocks. Since sales movements roughly coincide with the phases of the business cycle, inventory investment has proved to be strongly procyclical.

To understand more fully how inventory-to-sales (I-S) targets lead to procyclical inventory movements, consider how firms respond to a sustained decline in sales. If the decline is anticipated, firms may reduce production ahead of time, but once sales actually drop, the firms will still need to liquidate inventories if they wish to stay close to their target I-S ratio. If the slowdown is unanticipated, the required liquidation is even larger, because the unexpectedly low sales will cause inventories to accumulate quickly. Burdened with more stock just when they would like to have less, firms will need to divest themselves of this large inventory buildup to return to their target ratio.

This example also makes clear how inventory movements can intensify business cycle swings. Estimates suggest that slowdowns in inventory investment on average accounted for 24.5 percent, or roughly one-quarter, of the overall slowdown in GDP growth during postwar recessions (excluding the very brief 1980 recession). The latest recession is no exception: inventory investment contributed 20 percent to the reduction in GDP growth that began in the first quarter of 2001.

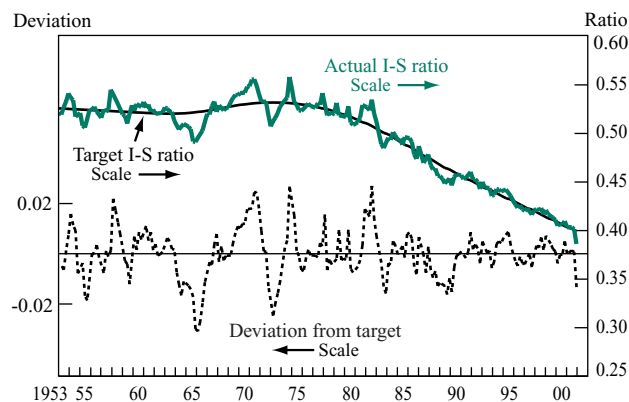
Although the basic relationship between inventory investment and the business cycle has remained the same throughout the postwar period, there is evidence that improvements in inventory management beginning in the early 1980s have altered the dynamics of this relationship (see, for example, Kahn, McConnell, and Perez-Quiros [2002]). First, inventory-to-sales ratios have been trending downward since the early-to-mid 1980s, an indication that firms can meet their customers’ needs with fewer stocks on hand (Chart 1). Second, inventory investment now contributes less to

the quarter-to-quarter volatility of GDP growth. The average contribution of inventory investment during expansions in the 1953-83 period was 0.52 percentage point, while the average for expansions in the 1983-2001 period was only 0.10 percentage point. Finally, I-S ratios now stay closer to their apparent trend or “target” (Chart 1), suggesting that producers and retailers may be making smaller forecasting mistakes.³

How could improved inventory management moderate the procyclical inventory movements described above? First, better information or forecasting techniques might help firms to predict changes in demand earlier and with much more accuracy. If firms had clear signals of, say, an upcoming slowdown, they could then reduce production to avert an unintended buildup of inventories. As a result, they would not need to liquidate vast amounts of stock to get inventories back on target once the slowdown began. Second, lower target inventory-to-sales ratios could diminish the response of inventory investment to sales fluctuations. For example, a firm seeking to maintain a low I-S ratio would not need to liquidate as much inventory for a given decline in sales as would a firm targeting a high ratio.

Changes in firm management of inventories may account for the pattern of inventory behavior in the 1990-91 recession, which differed markedly from that in earlier recessions. The inventory-to-sales ratio did not rise spectacularly at the onset of the 1990-91 recession, nor did it fall spectacularly at the beginning of the ensuing expansion. Better inventory control may have allowed firms to avoid both an unwanted accumulation of inventories early in the downturn and the sharp cut in inventories (and production) that typically occurs later. In addition, it may have helped to keep the overall decline in real output mild by historical standards, even allowing for the fact that the downturn in sales was modest.

Chart 1
Behavior of the Inventory-to-Sales Ratio



Source: Authors’ calculations, based on data from U.S. Bureau of Economic Analysis, National Income and Product Accounts.

Note: The ratio is based on annual sales of goods in 1996 dollars.

But while many signs suggest that inventory behavior and its relationship to the business cycle have changed, the latest recession seems to call these changes into question. The huge liquidation of inventories in the fourth quarter of 2001, following a substantial sell-off of inventories in the first three quarters, recalls the extreme inventory movements of recessions prior to 1984 and contrasts sharply with the more moderate movements observed in the 1990-91 recession. Does this mean that firms have not made as much progress in inventory management as some economists have thought? Or that inventory control cannot be an important source of the diminishing volatility of the business cycle? To explore these questions, we now undertake a

more precise comparison of inventory behavior in the 2001 recession and previous recessions.

Inventory Behavior Past and Present

For our comparison, we set the 2001 recession against an “average” or standardized recession that is representative of postwar recessions through 1983. This standardized recession is the contractionary phase of a larger “reference cycle” (see the box). We compare inventory behavior in the first three quarters of 2001 with inventory behavior in the reference cycle, and then separately discuss the huge liquidation that occurred in the fourth quarter of 2001.

Reference Cycles

Although all recessions share certain features, they differ in duration and magnitude. Here we draw on the work of Burns and Mitchell (1946) to present a method of constructing a representative or average business cycle. Following Burns and Mitchell's lead, we call this average cycle a *reference cycle*.

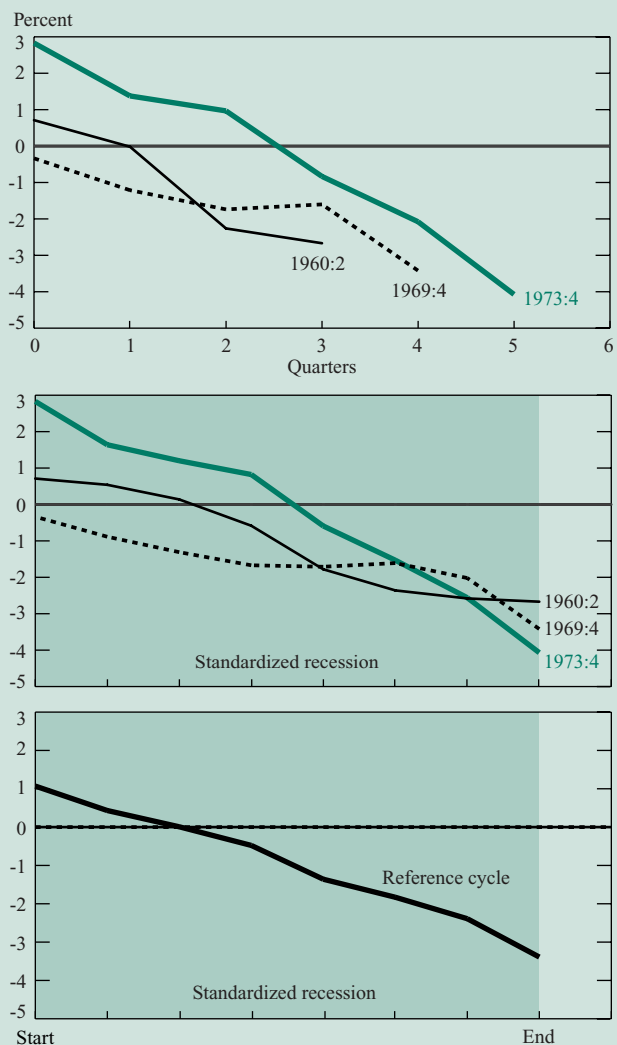
The method involves placing data from all recessions on the same horizontal scale, regardless of the recessions' actual duration in real time. Data from a short recession like the one in 1990-91 are stretched out, while those from a longer recession like the one that began in 1973 are condensed, so that on a graph the two cycles appear to be of equal length. A data series such as detrended final sales can then be compared across different recessions, or averaged over a group of recessions to obtain a representation of the typical cyclical behavior of that series.

The chart shows how a reference cycle is constructed for peak-to-trough detrended GDP. The top panel shows the series plotted in actual time for three different recessions of varying lengths. The middle panel shows the series scaled to the same length for each of the three recessions, and the bottom panel shows the average of the three re-scaled series. The horizontal scale of the middle and bottom panels is not demarcated in quarters, but in fractions of a recession. Thus, the typical behavior of this series, as averaged across the three recessions, is to be approximately 1 percent above trend at the peak, to fall to about 1 percent below trend by the midpoint of the recession, and to trough at nearly 4 percent below trend.

In our analysis, we will apply this method to data series averaged over postwar recessions through 1983, the year in which McConnell and Perez-Quiros (2000) find a break in GDP volatility. We then compare the behavior of the same series during the 2001 recession with the historical behavior represented by the averages.

Constructing a Reference Cycle

Peak-to-Trough Decline in GDP



Source: Authors' calculations. Peak and trough dates are as defined by the National Bureau of Economic Research.

We find that the 2001 recession differs significantly from earlier recessions in the timing of the inventory liquidation (Chart 2, top panel). In the reference cycle, inventory investment was generally positive and steady for the first two quarters prior to the start of the downturn, and remained positive almost halfway through the recession. In the case of the 2001 recession, however, inventory investment slowed markedly prior to the start of the downturn, and was actually negative in the first quarter of the recession.

As a result of the early liquidation of inventories in the 2001 recession, the behavior of the inventory-to-sales ratio relative to its target also differed from its past behavior (Chart 2, middle panel). In the earlier recessions, as sales began to slow or decline, inventories accumulated (presumably unintentionally). Consequently, the inventory-to-sales ratio rose steadily in the first part of the recession. Such an increase in the ratio would exacerbate the economic slowdown because eventually producers would need to cut production not only to match slower sales, but also to liquidate these excess inventories.

In the 2001 recession, by contrast, the inventory-to-sales ratio hovered remarkably close to target during the first three quarters of 2001. The behavior of the ratio suggests that firms were anticipating the slowdown and intentionally trimming inventories in order to avoid a buildup and the resulting need for further production cuts well into the recession. Thus, the I-S ratio never really rose during the recession, with the result that even larger production cuts to work off excess inventories were not required.

The stark contrast in the behavior of the inventory-to-sales ratio in the 2001 recession and the reference cycle provides strong evidence that the latest downturn—at least in the first three quarters—was not a return to an earlier, less effective mode of inventory management. Firms appear to have been very successful in managing their inventories to avoid the sharp changes in production that can contribute to output volatility.

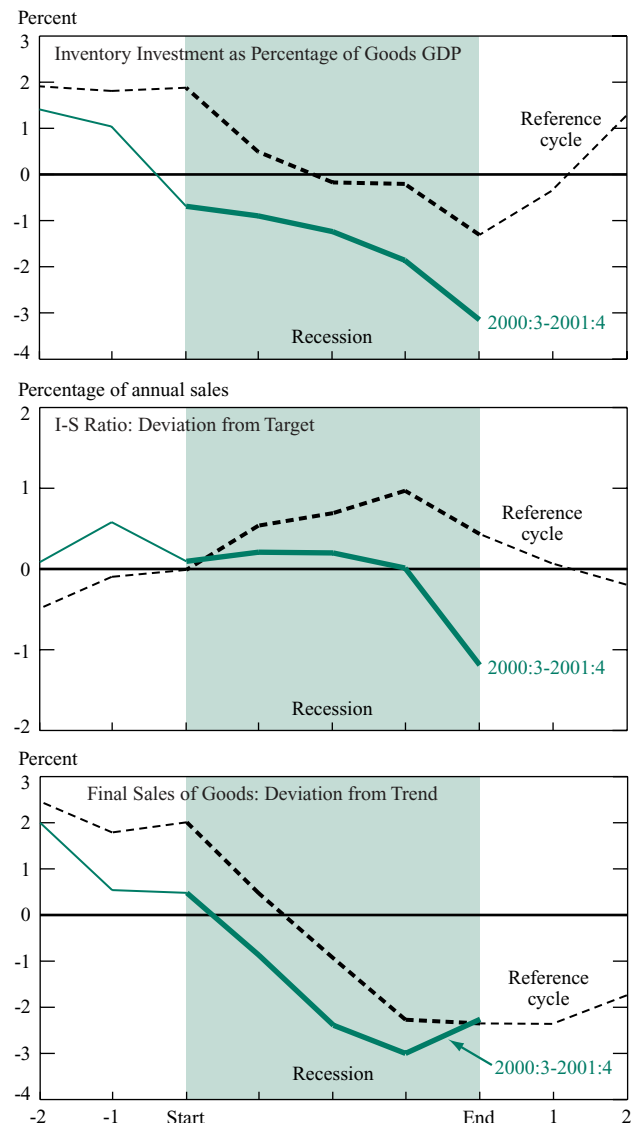
Nevertheless, we still have to address the huge liquidation in the fourth quarter of the 2001 recession. Is it possible to reconcile this development with the notion that firms are doing a better job of controlling their inventories?

The Fourth-Quarter Puzzle

The \$114 billion reduction in inventories in fourth-quarter 2001 was one of the largest in history, whether considered in dollar terms or as a percentage of output. The inventory reductions were spread fairly evenly across the manufacturing, wholesale, and retail trade sectors of the economy, although the liquidation of retail autos made a disproportionate contribution to the overall reduction.

To clarify why there was such a dramatic rundown in inventories in the fourth quarter, we return to our comparison of the 2001 recession and the reference cycle. This time, we focus on the behavior of final sales in the last quarter of the 2001 downturn relative to their behavior at the end of the earlier recessions. Although sales followed the same steady decline in the first three quarters of 2001 as they had in previous recessions, the fourth quarter of 2001 saw an abrupt surge in sales that had no parallel in pre-1984 recessions (Chart 2, bottom panel). Sales moved about 1 percentage point closer to trend, a gain equivalent to an 8 percent annualized rate of growth.

Chart 2
Inventory Investment and Sales: Comparing the 2001 Recession with the Reference Cycle



Source: Authors' calculations, based on data from U.S. Bureau of Economic Analysis, National Income and Product Accounts.

Note: The reference cycle represents a standardized business cycle, here calculated as an average of postwar cycles through 1983.

This jump in sales growth explains much of the fourth-quarter liquidation. It suggests that firms did not make a calculated decision to sell off large quantities of inventories but were instead caught off guard by a rise in demand that drained inventories rapidly. Supporting this interpretation is the fact that firms actually increased production in the fourth quarter—an indication that they had meant to end the quarter with replenished stocks. Our estimate of the target I-S ratio implies that nearly half, or \$51 billion, of the \$114 billion inventory liquidation in the fourth quarter was unintended.

That firms were unprepared for a sharp increase in demand is not surprising. As our reference cycle indicates, past experience would have led producers to expect the downturn in final sales to continue longer. Moreover, the events of September 11 added considerable uncertainty to the business outlook and gave firms reason to believe that future sales would be depressed. Even in ordinary times, turning points in sales have proved extremely difficult to predict.

As a result of the mistaken sales forecast and the consequent drop in inventories, the inventory-to-sales ratio fell far below its target (Chart 2, middle panel). Nevertheless, the deviation from target—here termed the inventory gap—was not unusually large by historical standards. Gaps of this magnitude had occurred on other occasions after the early 1980s, and the fourth-quarter miss was clearly dwarfed by the deviations that had occurred before 1984 (Chart 1).

What is unusual, however, is for the inventory-to-sales ratio to fall below target during a recession. As we showed above (Chart 2, middle panel), weakening demand usually precipitates a buildup in inventories that keeps firms above their target I-S ratios well into a recession. Thus, the liquidation that typically takes place at the onset of recovery helps businesses get their swollen inventories down to more desirable levels. In 2001, however, the liquidation in the fourth quarter left businesses with record-low inventory-to-sales ratios.

Implications for the Recovery

With even moderate growth in final sales, a below-target inventory-to-sales ratio will fuel strong output growth in the short run. The reason for this is that if firms are to bring their inventories back up to target, they will need to boost production considerably. Thus, although firms' low I-S ratios stemmed largely from an error in forecasting sales growth, that error may prove to be a source of strength as the economy recovers.

In order to assess the influence of inventory conditions on the GDP outlook for 2002, we consider three factors—the inventory gap as of fourth-quarter 2001, an econometric estimate of the typical speed with which a gap is closed, and an assumption about the path of final sales growth in 2002.⁴ We combine this information in a simulation to produce an estimate for GDP growth for 2002. We also produce a path for the inventory-to-sales ratio and for the gap over this same time period.

We find that the inventory gap provides a strong stimulus to output growth in the early part of 2002, resulting in 5.9 percent growth in the first quarter (see table).⁵ Growth for 2002 as a whole is 4.6 percent. The inventory-to-sales ratio, however, does not begin to move closer to its target until the second half of 2002. The gap is then eliminated gradually over the next one to two years.

Although one to two years may seem a long horizon for correcting an error made in a single quarter, it is not really surprising. The gap, after all, is a direct consequence of a shortfall of production relative to sales. With such a running start for sales, it is difficult for production even to catch up, much less surpass sales and begin to reduce the gap. In the fourth quarter of 2001, the gap was 1.35 percent, reflecting the fact that sales exceeded production in the goods sector by nearly 3 percent. Even with moderate sales growth at, say, a 2 percent annualized rate, goods sector output would have to increase by 3.5 percent in one quarter (or at roughly a 15 percent annual rate) just to keep the gap from growing larger. Such a jump in production is

Quantifying the Impact of the Inventory Gap on GDP Growth

	Baseline Scenario				Counterfactual Scenario			
	Growth		I-S		Growth		I-S	
	Sales	GDP	Ratio ^a	Gap ^a	Sales	GDP	Ratio ^a	Gap ^a
2001:4	3.8	1.7	38.4	-1.3	-0.2	1.7	39.8	0
2002:1	2.6	5.9	37.9	-1.8	2.6	3.3	39.3	-0.4
2002:2	2.0	4.8	37.8	-1.7	2.0	3.1	39.1	-0.5
2002:3	2.8	4.3	37.9	-1.5	2.8	3.5	38.8	-0.6
2002:4	2.7	3.4	38.1	-1.1	2.7	3.3	38.7	-0.6
2002	2.5	4.6			2.5	3.3		

Notes: The I-S gap is the difference between the actual and the targeted inventory-to-sales ratio. The shaded figures are drawn from actual data; the remaining figures are simulated values.

^aCalculated as a percentage of annual sales.

unlikely. Indeed, the simulation shows the gap actually growing to 1.8 percent in the second quarter, and remaining above 1 percent at the end of 2002.⁶

To isolate the contribution of the gap to GDP growth, we consider a counterfactual scenario in which sales in the fourth quarter of 2001 are sufficiently lower to preclude an inventory gap, but then grow at the same rate as in the previous simulation for 2002. We find that without a gap in the fourth quarter of 2001, GDP growth moderates substantially. For the first quarter of 2002, GDP growth is 3.3 percent, compared with 5.9 percent in the baseline scenario; for the year, it is also 3.3 percent, compared with 4.6 percent in the baseline (see table). This exercise suggests that the inventory shortfall could be a significant impetus to output growth during the recovery.

Conclusion

This article investigates whether the massive inventory liquidation that took place during 2001 undermines the view that businesses have improved their management of inventories. Our conclusion is that better inventory control was in fact evident through the first three quarters of 2001. We point to the fact that inventories were liquidated in a more timely fashion than has been typical in past business cycles, and that as a consequence, firms avoided large unintended run-ups in their inventory-to-sales ratios as well as the even larger liquidation that such run-ups imply.

We also conclude that the fourth-quarter liquidation was probably unintended, a result of sales growing faster than businesses had anticipated. We argue both that the resulting inventory shortfall was not particularly large by historical standards, and that a number of extenuating circumstances probably contributed to it—namely, the heightened uncertainty created by the events of September 11 as well as the unusually short duration of this recession.

Finally, we assess what current inventory levels imply for the recovery. Our simulation exercise suggests that the inventory shortfall created by the liquidations of 2001 could trigger increased production and add more than 1 percentage point to 2002 GDP growth.

About the Authors

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The views expressed in this article are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

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Notes

1. Figures are in current dollars, at annual rates.
2. Alan Greenspan summed up this view in a 1999 speech: “The dramatic changes in information technology that have enabled businesses to embrace the techniques of just-in-time inventory management appear to have reduced that part of the business cycle that is attributable to inventory fluctuations” (“New Challenges for Monetary Policy,” available at <http://www.federalreserve.gov/boarddocs/speeches/1999/19990827.htm>).
3. Although the smaller deviations from trend could simply reflect a decline in sales volatility, Kahn, McConnell, and Perez-Quiros (2002) provide evidence supporting the hypothesis of improved inventory control. Our estimate of the target ratio is an HP filter of the actual data, using a smoothing parameter of 32,000.
4. For this exercise, we use the average of two privately produced forecasts of real final sales growth from the first quarter of 2002. The first was provided to us by Edward Leamer of the Anderson School at UCLA, and the second by Macroeconomic Advisors, LLC.
5. As this article went to press, the report on GDP growth supported this prediction, with first-quarter GDP growth at an estimated 5.6 percent annual rate.
6. In moving from the goods sector to aggregate GDP, we also take into account the fact that goods sector sales and output are typically more cyclical than the rest of the economy. So, for example, a forecast of 2 percent aggregate final sales growth would correspond in our model to 3 percent growth of goods sector sales and 1.4 percent growth of sales in services and structures.

References

- Burns, A. F., and Wesley C. Mitchell. 1946. *Measuring Business Cycles*. National Bureau of Economic Research.
- Kahn, James A., Margaret M. McConnell, and Gabriel Perez-Quiros. 2002. “On the Causes of the Increased Stability of the U.S. Economy.” *Economic Policy Review* 8, no. 1 (May): 183-202.
- McConnell, Margaret M., and Gabriel Perez-Quiros. 2000. “Output Fluctuations in the United States: What Has Changed since the Early 1980s?” *American Economic Review* 90, no. 5 (December): 1464-76.