THE MYTH OF DECLINE: ASSESSING TIME TRENDS IN U.S. INVENTORY-SALES RATIOS

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This report is released to inform interested parties of ongoing research and encourage discussion on work in progress. The views expressed on statistical, methodological, technical, or operational issues are those of the author and not necessarily those of the U.S. Census Bureau.

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Abstract

There is a widely held perception that improved supply chain practices and new technologies have led to declines in the inventory-sales ratio. Our empirical analyses of 87 inventory-sales ratios in 45 manufacturing, wholesale distribution, and retail trade industries casts doubt on assumptions of widespread declines in these ratios. We find that less than half of the ratios showed statistically significant declines during the 12 year period from January 1992 through December 2003. Information technology may indeed have improved inventory management, but this improvement is not reflected in inventory-sales ratio data for many U.S. industries. Our detailed case study of the pharmaceutical supply chain also offers additional insights by showing how relevant technological investments led to an extended period in which inventory-to-sales ratios increased.

1. Introduction

There is a widely held perception that improved supply chain practices and new technologies have led to declines in the inventory-sales ratio. The logic is straightforward. Companies in goods-handling industries have invested substantial sums to implement new information technology-based supply chain practices such as just-in-time (JIT) inventory management and the introduction of bar codes. These new practices have allowed firms to improve their management of orders and stockpiles of materials and thereby cut their inventory-to-sales ratio.

This view finds general empirical support because the inventory-sales ratio, as reported by the Bureau of Economic Analysis' National Income and Product Accounts (NIPA), has declined contemporaneously with the adoption of these new practices as reported in the business press (Allen 1995, Willis 2003). Federal Reserve Chairman Alan Greenspan supported this view by commenting that "…the remarkable surge in the availability of real-time information in recent years has sharply reduced the degree of uncertainty confronting business management. This has enabled businesses to remove large swaths of now unnecessary inventory, and dispense with much programmed worker and capital redundancies" (Greenspan 1999).

Other policy makers also appear to believe in the conceptual link between declining inventory-sales ratios and technology. In testimony to the United States Senate, Federal Reserve Bank of New York Senior Vice President Charles Steindel stated that "…the inventory-sales ratio in manufacturing has declined almost continuously since the early 1990s, which we think is consistent with improved inventory management techniques." (Steindel 1999). Vice Chairman of the Federal Reserve Board Ferguson offered additional support by noting that "… investments in information technologies have helped firms to cut back on the volume of inventories that they

hold as a precaution against glitches in their supply chain or as a hedge against unexpected increases in aggregate demand" (Ferguson 2001).

The belief in a declining inventory-sales ratio has also stimulated development of theoretical models to explain time trends in NIPA inventory-sales ratio data. Kahn et al (2001, 2002) interpret declining volatility in inventories relative to volatility in sales as evidence that "…could be plausibly linked to improvements in information technology" (Kahn et al 2002, p. 187). The stylized empirical findings are used to build a mathematical model of firm-level inventory management behavior to explain macroeconomic effects such as a moderation in GDP volatility. David (2001) suggests that information technology allows fuller utilization of fixed assets, thereby relating observed productivity growth in the 1990s to the purported declines in the inventory-sales ratio.

Finally, at least some private companies invest in supply chain technology based on this belief. A 2003 survey found that 56 percent of supply chain management software buyers name "reducing inventory" as the most important factor fueling their investment in supply chain technology.[1]

However, an important linchpin of the conceptual link between technology and inventory-sales ratios is undermined if inventory-sales ratios have not actually been declining. For example, Filardo (1995) argues the aggregate manufacturing, wholesale trade, and retail trade inventory-sales ratio have all remained within their historical ranges. Stock and Watson (2002) show that the relative volatility of inventories and sales has not changed as much as previously estimated by using more sensitive statistical tests. Khan (2003) questions the impact of technological innovation on the aggregate inventory-sales ratio by noting that the nominal inventory-sales ratio rose before it fell. Ginter and La Londe (2001), in one of the few studies to

[1] "Inventory Optimization – A Delicate Balance," *FrontLine Solutions*, April 2004.

use financial statements from public companies instead of government data, conclude that some industries have seen substantial declines, while others have shown no improvement or shown an increase in inventory levels.

Consider the inventory-sales ratio for three most important goods-handling sectors – manufacturing, merchant wholesale trade, and retail trade. (See Exhibit 1.) Although the manufacturing and retail series appear to be trending downward over this 12 year period, the variability in the series makes it difficult to declare a statistically significant decline by the end of the period.

INSERT Exhibit 1 ABOUT HERE

In this paper, we directly evaluate time trends in 87 inventory-sales ratios from 45 manufacturing, wholesale distribution, and retail trade industries. Our empirical results cast doubt on a broadly declining inventory-sales ratio. After controlling for the time series characteristics of inventory-sales ratios, we find that less than half of the ratios showed statistically significant declines during the 12 year period from January 1992 through December 2003. The inventory-sales ratio actually increased in a number of industries, while many showed no statistically significant change. In other words, information technology may indeed have improved inventory management, but this improvement is not reflected in inventory-sales ratio data for many U.S. industries.

This paper makes four important contributions to the discussion of inventory-sales ratios. One, we disaggregate sector level trends to highlight the specific industries in which inventory-sales ratios have been changing, whereas previous studies have generally examined sector or economy-wide aggregations, whereas. As Ramey and Vine (2004) highlight, shifts in the sales

or relative price levels of underlying sub-sector (industry) components can cause the aggregate ratios to behave much differently than disaggregated ratios.

Two, this paper improves on previous studies by utilizing time-series econometric methods for identifying time trends and accounting for both variability and measurement errors in the data. Inventory and sales data, which are collected by the U.S. Census Bureau using mail surveys, are subject to both sampling and non-sampling error. In contrast, many economists have relied on visual inspection of graphs or simply compared two arbitrary points in time.

Three, we explicitly consider important definitional differences between alternative data sources reported by various government agencies, a previously unacknowledged methodological complication in analyzing time trends.

Four, our inclusion of wholesale and retail trade sectors is unusual. Most empirical research has focused on manufacturing inventories (Ramey and West 1997) despite the fact that the value of wholesale and retail inventories are larger.

Our case study of the pharmaceutical supply chain also offers a counter-point to the perception that information technology leads to falling inventory-sales ratios throughout a supply chain. Instead of technology per se, the explanation for the time trends in inventory-sales ratios comes from a series of business policy decisions made by wholesalers and manufacturers. We argue that pharmaceutical wholesalers strategically elected to hold additional inventory relative to sales levels because of their technology-enhanced capabilities to forward buy inventories, profiting from the product price inflation. In other words, the inventory-sales ratio increased because of investments in information technology. However, recent manufacturer-wholesaler business agreements have led to a reversal of this trend and a declining inventory-sales ratio.

This paper is organized as follows. In the next section, we review the definitional issues surrounding the measurement of inventory-sales ratios and describe our data set. Section three describes our analysis approach. Section four summarizes the quantitative results of our empirical analyses. We discuss two supply chain case studies in Section five. Section six summarizes the major implications, identifies limitations to our study, and suggests directions for further research.

2. Data

To understand movements in inventory-sales ratios over time, we examined the three major goods handling sectors of the economy – manufacturing, merchant wholesale trade (wholesale distribution), and retail trade.

Industry level inventory-sales ratios are reported both by the Bureau of Economic Analysis using the National Income and Product Accounts (NIPA) and by the Bureau of the Census using the Manufacturing and Trade Inventories and Sales (MTIS) report.[2] Few studies have considered the definitional and methodological differences between these alternative data sources.[3]

One important difference between NIPA and MTIS data is the definition of inventory. NIPA reports replacement cost data, whereas MTIS reports inventories on a current cost basis. In practice, the Bureau of Economic Analysis, which produces the NIPA data, revalues the inventory data in the Census Bureau's MTIS report from current cost to current replacement cost. The revaluation amount, which is called the inventory valuation adjustment, removes

[2] The estimates in the MTIS are based on data from three surveys: the Monthly Retail Trade Survey, the Monthly Wholesale Trade Survey, and the Manufacturers' Shipments, Inventories, and Orders Survey.

[3] Our discussion of NIPA data is limited to the sector or industry level estimates. Studies examining economy-wide ratios of non-farm inventories to final sales, such as Allen (1995), suffer from a serious conceptual flaw. NIPA final sales – the sum of all goods and services sold – includes many firms that do not contribute to the inventory number and also leaves out some firms that hold inventories. (See Filardo 1995, footnote 9.) For example, the aggregate ratio includes services in the denominator but not the numerator since a service can not be "held" in physical inventory. The current study only examines goods handling industries.

ordinary gains and losses that could come from holding inventories purchased at prices either higher or lower than current cost.

Another important difference between NIPA and MTIS data comes from the adjustment from nominal to real dollars. MTIS reports current sales or shipment activities.[4] In contrast, NIPA reports real sales and inventories dollars using a chain-type quantity index and a base year of 2000 current dollars.[5]

Thus, NIPA inventory-sales ratio data is computed as (a) Real chained-dollar inventories, valued at replacement cost, seasonally adjusted, divided by (b) Real chained-dollar sales, seasonally adjusted. Seasonal factors are applied separately to each series prior to computing the ratio. MTIS inventory-sales ratio data is computed as (a) Nominal current cost inventories divided by (b) Current sales. MTIS reports both seasonally adjusted and non-adjusted data.

Our analyses focus on current cost, nominal inventory-sales ratios, which are available from MTIS. Current cost is a better measure of inventory-sales ratios because the numerator and denominator of the inventory-sales ratio are directly comparable as contemporaneous measures of supply chain activity. For example, the nominal ratio reflects a firm's working capital requirements for financing the dollar value of inventories. Since the ratio is denominated in months, the current-cost measure from MTIS data provides is more appropriate measure of the time until restocking. In contrast, chained-dollar (real) data do not accurately reflect the true value at any given point in time due to the base year adjustment and weighting factors.

[4] Complete definitions for both sales and inventories on the various monthly surveys are available on the U.S. Census Bureau web site. For wholesale trade, see http://www.census.gov/svsd/www/mwtsdef.html. For manufacturing, see http://www.census.gov/indicator/www/m3/m3desc.pdf. For retail, see http://www.census.gov/mrts/www/summary.html.

[5] See "Real Inventories, Sales, and Inventory-Sales Ratios for Manufacturing and Trade, 1997:I–2003:IV," *Survey of Current Business*, April 2004. (Available at www.bea.gov/bea/ARTICLES/2004/04April/0404ISR.pdf.)

By eliminating capital gains, the replacement cost inventory data in NIPA may not reflect firm-level decisions about the appropriate amount of inventory to hold, although NIPA figures clearly are a more appropriate measure of income for computing national income. Current cost will also be a better measure if firms expect to profit from product price increases, as in the case of pharmaceutical wholesalers described in section 5. In practice, the pattern of the current dollar ratios based on pre-LIFO inventories differ from current-dollar ratios based on replacement-cost inventories,[6] although it not possible to compute the precise difference using published data.

Our decision to rely on current cost inventory data leads us to MTIS for sales data since the Census Bureau does not report real inventory-sales ratio estimates. However, real and nominal current cost inventory ratios should present similar stories because we are conducting industry-level (sub-sector) analyses. As Ramey and Vine (2004) demonstrate, the discrepancy between aggregate real and nominal inventory-sales ratios has occurred because price increases for services have been much greater than for goods. We can generalize their argument by noting that any nominal inventory-sales ratio is affected by relative price changes in the underlying aggregated components. Our analyses focus on industry-level time trends rather than the sector-level patterns of Exhibit 1, so changes in relative prices should have similar effects on sales and inventories within a particular NAICS industry.

We collected publicly available monthly, seasonally unadjusted sales and inventories from the U.S. Census Bureau's web site in May 2004. Exhibit 2 summarizes the available time series. Data for manufacturing industries included three stages of production – materials and

[6] *ibid.*

supplies, work-in-progress, and finished goods – yielding 87 total data series from 45 industries.[7] This dataset represents the most disaggregated level of analysis possible with publicly available data.

INSERT Exhibit 2 ABOUT HERE

All of the series cover the 144 month period from January 1992 through December 2003. As noted by prior studies (Allen 1995, Willis 2003), anecdotal evidence suggests that relevant supply chain technology adoption was occurring throughout this period and therefore should be apparent in inventory-sales ratios.

3. Methodology

There are no standard econometric techniques to identify a long-term trend component in time series data. Therefore, we use a very general approach based upon the econometric literature on unit roots in economic time series data. Our approach incorporates information about the variability in the data as well as measurement error.

Consider the following model:

$$IS_t = \alpha + \beta t + \rho IS_{t-1} + \varepsilon_t \qquad (1)$$

where

IS = Inventory-sales ratio

t = time trend

The time pattern of an inventory-sales ratio that does not increase or decrease over time will empirically appear to be a *stationary process*. In other words, the ratio will tend to return to its mean value rather than trend up or down. The data generating process for a stationary series will have $\beta = \rho = 0$ in equation (1).

[7] Technically, the tabulated manufacturing categories from the M3 survey are groupings of manufacturing industries defined in NAICS. We refer to the M3 groupings as "industries" in this paper for consistency of presentation.

Alternatively, the ratio could be a *trend stationary process*. A trend stationary series evolves around a steady upward or downward sloping curve without big swings away from that curve. In other words, the mean grows around a deterministic trend at a constant rate. Any deviation from its long run growth path βt is temporary. The data generating process for a trend stationary series will have $\beta \neq 0$ and $\rho < 1$ in equation (1).

If an inventory-sales time series is generated by a stationary process (with or without a trend), then standard econometric estimation of equation (1) could proceed. The presence or absence of a trend would be determined by evaluating the sign and significance of the estimated β coefficient.

However, if $\rho = 1$, the time series is said to have a unit root and statistical inference on equation (1) is flawed. The time series is *non-stationary*. Any temporary deviation from its long run growth path persists over time. The inclusion of a deterministic time trend in a non-stationary series does not remove this evolution. The data generating process for a non-stationary series will have $\beta = 0$ and $\rho = 1$ in equation (1).

If $\alpha = 0$ as well, then the time series is generated as a random walk without drift. Since the series is non-stationary, statistical inference on this series may (incorrectly) conclude that a trend is present although there is no time trend in the underlying data generating process. If $\alpha \neq 0$, then the series is generated as a random walk with drift and has a stochastic time trend.

The outcomes above suggest an empirical testing framework based on the unit root properties of a given inventory-sales time series. Transforming equation (1) yields:

$$\Delta IS_t = \alpha + \beta t + (\rho-1)IS_{t-1} + \varepsilon_t \qquad (2)$$

$$= \alpha + \beta t + \gamma IS_{t-1} + \varepsilon_t$$

this is the functional form of the well-known Dickey-Fuller test. The test statistic is the t-statistic for $\gamma = 0$ using special critical values to reflect its non-normal distribution under the null of a unit root.[8] This test is one-sided because the alternative hypothesis ($\rho > 1$) implies unreasonable explosive behavior.

The Augmented Dickey-Fuller (ADF) test with lagged dependent variables is appropriate when there is the possibility of serial correlation in ε_t:

$$\Delta IS_t = \alpha + \beta t + \gamma IS_{t-1} + \Sigma \lambda_j \Delta IS_{t-j} + \varepsilon_t \qquad (3)$$

Experimentation with alternative lag specifications for the 87 data series indicated that the empirical results were robust for $j>1$.

For each of the 87 data series described in section 2, we employ a sequential testing strategy that begins with equation (3) and proceeds based on one of the two possible outcomes:

- **Outcome 1:** Reject the null of a unit root, implying no unit root and the use of conventional estimation and testing procedures. Test for a deterministic trend by conducting a t-test of the null that $\beta=0$ using standard critical values.

Outcome of Second-stage Test	Statistical Conclusion
• If we reject the null, then we determine the slope of the deterministic trend by the sign of β.	• The inventory-sales ratio has changed over the sample period.
• If we fail to reject the null that $\beta=0$ at this point, then we can reject the presence of both a deterministic and a stochastic trend.	• The inventory-sales ratio has not changed over the sample period.

[8] We use the response function formula developed by MacKinnon (1991) to generate appropriate critical values.

- **Outcome 2:** Fail to reject the null of $\gamma=0$, implying the presence of a unit root with or without drift. Constrain $\gamma=\beta=0$ and re-estimate the model. Test $\alpha=0$.

Outcome of Second-stage Test	Statistical Conclusion
• If we fail to reject the null, then the time series is empirically equivalent to a random walk with no trend over time.	• The inventory-sales ratio has not changed over the sample period.
• If we reject the null (such that $\alpha \neq 0$), then the time series has a stochastic time trend	• The inventory-sales ratio has changed over the sample period.

All statistical tests were conducted at the 0.01 significance level, although the results were virtually identical at the 0.05 significance level. In practice, we failed to reject the null of $\gamma=0$, implying a unit root in only nine of the 87 data series. The second stage test for all nine data series were empirically equivalent to a random walk with no stochastic time trend, i.e., $\alpha = 0$.

Note that the results from our statistical analysis may differ from a naïve approach that merely compares two different points in time. Given the variability in inventory-sales ratios, point comparisons will not portray a complete picture of time trends because the results are extremely sensitive to the particular end-points chosen.

Our approach has the additional benefit of incorporating measurement error in the dependent variable. The inventory-sales ratio is an estimate based on a sample survey and is subject to both sampling and non-sampling errors.[9] However, measurement error of the

[9] Technical documentation is available on the U.S. Census Bureau web site. The explanatory material for wholesale trade provides a detailed discussion of reliability. See http://www.census.gov/svsd/www/appendixa.html.

dependent variable is absorbed into the disturbance and can effectively be ignored as long as ε_t conforms to the assumptions of the classical regression model (Greene 1993). Our empirical approach directly evaluates the appropriateness of the regression estimates. The use of the ADF test minimizes any inference problems due to serial correlation.

For presentation purposes, we also report the average estimated slope for each of the major sectors. The estimated slope was computed for each inventory-sales time series as the estimated coefficient from a linear regression of the inventory-sales ratio on a linear time trend. This is equivalent to equation (1) with $\rho = 0$. Although hypothesis testing of this coefficient will be incorrect, a least-squares regression will provide an unbiased estimate of β.

4. Empirical Results

Our analyses found substantial variability in inventory-sales ratios among the 45 industries and 87 time-series within the three primary goods-handling sectors. (See Exhibit 3.)

- 41 (47 percent) of the series had a statistically significant decline in the inventory-sales ratio.
- 34 (39 percent) of the series had no statistically significant change in the inventory-sales ratio.
- 12 (14 percent) of the series had a statistically significant increase in the inventory-sales ratio.

INSERT Exhibit 3 ABOUT HERE

In other words, more than half of the series did not provide evidence for a decline in the inventory-sales ratio. In the following sections, we review the detailed results by sector.

4.1. Manufacturing

Trends in inventory-sales ratios at the three stages of the manufacturing process varied substantially within industries.

- The 12 year time trend was the same (negative) for all three stages of processing in only three industries – Printing (23S), Fabricated Metal Products (32S), and Furniture and Related Products (37S).
- The 12 year time trend was different for all three stages of processing in four industries – Beverage & tobacco products (12S), Textile Products (14S), Leather and Allied Products (16S), and Primary Metals (31S).
- The remaining 14 industries had various patterns across the three different stages of processing.

These disparate patterns suggest that any hypothesized supply chain efficiencies have not been equally shared throughout the manufacturing supply chain. Manufacturers appear to have seen the greatest improvements in internal processes (work in progress), possibly through productivity gains, lean manufacturing techniques, and better forecasting of materials requirements. Downstream supply chain efficiencies with finished goods have not seen similar levels of declines in inventory-sales ratios. Perhaps it is simply easier for companies to improve internal processes versus cross-company coordination within the supply chain.

4.1.1. Materials/Supplies

Nearly half of manufacturing industries showed a significant decrease in materials & supplies inventory-sales ratios between 1992 and 2003.

- Ten of the manufacturing industries experienced a significant decline in the inventory-sales ratio at the materials/supplies state of processing.

- Nine of the manufacturing industries saw no statistically significant change.
- Two industries – Primary Metal manufacturers (M3 Category 31S) and Textiles manufacturers (M3 Category 13S) – had statistically significant increases in the inventory-sales ratio between 1992 and 2003.

Exhibit 4 summarizes the results for the 21 manufacturing industries in our study.

INSERT Exhibit 4 ABOUT HERE

The time trend in certain industries suggested that factors beyond information technology were more important to changes in the inventory-sales ratio. Consider Electronic Equipment, Appliances and Components (M3 Code 35S), which was classified as a stage of processing with no change in its inventory-sales ratio. As Exhibit 5 shows, the industry has experienced at least three distinct periods of declining inventory-sales ratios over the past twelve years, each of which has been separated by short periods of increasing inventory-sales ratios. The overall trend has been neither consistently negative nor positive.

INSERT Exhibit 5 ABOUT HERE

4.1.2. Work-in-Progress

The work-in-progress stage of the manufacturing process evidenced the greatest number of industries with significant declines in the inventory-sales ratio:

- 13 manufacturing industries experienced a statistically significant decline in the inventory-sales ratio at the work-in-progress stage of production.
- Seven manufacturing industries saw no change in inventory-sales ratios.
- Only one industry – Beverage and Tobacco Product Manufacturing (M3 Category 12S) – had an increase in inventory-sales ratios at the work-in-progress stage of production.

Exhibit 6 summarizes the results for the 21 manufacturing industries in our study at the work-in-progress level of processing.

INSERT Exhibit 6 ABOUT HERE

4.1.3. Finished Goods

Finished goods had the lowest proportion of industries with inventory-sales declines among the three stages of processing:

- Only four of the 21 industries experienced a declining inventory-sales ratio for finished goods.
- Twelve of the manufacturing industries had no statistically significant change in inventory-sales ratios for finished goods.
- Inventory-sales ratios at the finished goods stage of processing increased in five manufacturing industries.

Exhibit 7 summarizes the results for the 21 manufacturing industries in our study for finished goods.

INSERT Exhibit 7 ABOUT HERE

There were also unexpected time series trends that appear to undermine a view of declining inventory-sales ratios. Exhibit 8 shows the inventory-sales ratio for Plastics and Rubber Products (M3 Code 26S), which was classified as a stage of processing with no change in inventory-sales ratio due to variance in the time series. However, the inventory-sales ratio appears to have increased in the last four years of the sample period, a pattern at odds with information-technology based stories of ratio decline.

INSERT Exhibit 8 ABOUT HERE

4.2. Merchant Wholesale Trade

Although the aggregate inventory-sales ratio for wholesale distribution (merchant wholesale trade) did exhibit a mild decline, we found substantial variation among the 18 4-digit NAICS industries in our sample:

- Only nine merchant wholesale trade industries had a statistically significant decline in inventory-sales ratios.
- Five wholesale industries had no statistically significant change in their inventory-sales ratios.
- Four wholesale industries experienced increasing inventory-sales ratios.

These results are also surprising given that the wholesaler's role as an intermediary depends on detailed knowledge of efficient goods-handling and inventory management. Exhibit 9 lists the detailed results for the 18 merchant wholesale trade industries by group. No clear pattern was apparent based on observable industry characteristics, although positive inventory-sales ratio trends were more common among durable goods wholesale industries (NAICS 421) than non-durable goods industries (NAICS 422). One-third of durable goods categories posted significant increases in their inventory-sales ratios in the period of study.

INSERT Exhibit 9 ABOUT HERE

Among those industries with significant declines, the largest absolute drops in inventory-sales ratios between 1992 through 2003 occurred in professional and commercial equipment (NAICS 4214) and electrical goods (NAICS 4216) (See Exhibit 9, column 6). The inventory-sales ratio for each of these industries declined by more than 20 percent over the twelve-year span of our study. Two industries posted double-digit increases – Metals and Minerals (NAICS 4215) and Farm Product Raw Materials (NAICS 4225).

4.3. Retail

Inventory-sales ratio declined significantly in 5 of the 6 three-digit NAICS retail trade industries we studied. One industry experienced no change and none increased. (See Exhibit 10.)

INSERT Exhibit 10 ABOUT HERE

In contrast to the other sectors, these declines are consistent with conventional views about supply chain efficiencies in retail. Retailing today is increasingly dominated by chain stores, warehouse clubs, and big box retailers. These retailers use information technology to gather product information, determine product price and availability, receive technical support or place orders – all without interacting directly with their suppliers' employees.

In many ways, Wal-Mart has been an early adopter of these technologies (Stalk et al 1992) by requiring suppliers to accept electronic orders, cut out middlemen, and now, acquire radio frequency identification technology and move to scan-based trading. Wal-Mart is the largest and arguably most influential retailer, with 2003 global sales exceeding $256 billion and more than 3,000 stores.[10] Wal-Mart is both the largest U.S. retailer of groceries[11] and one of the largest retailers of pharmacy products[12] in the United States, magnifying its influence across multiple retail product categories.

5. Pharmaceutical Supply Chain Case Study

The pharmaceutical wholesale industry provides an intriguing counter-factual situation in which information technology investments have not led to a decline in the inventory-sales ratio. Despite relevant technological investments, we did not observe the expected consistent, widespread declines in inventory-sales ratios throughout the supply chain. Instead, new

[10] Wal Mart Stores, Inc., Form 10-K, filed April 9, 2004.
[11] "Wal-Mart's the 1," *Progressive Grocer*, May 1, 2003.
[12] "Mass Merchants: Discounters aggressively pursue Rx dollars," *Drug Store News*, April 19, 2004.

information technology-based supply chain practices appear to have contributed to a period of increasing inventory-to-sales ratio between 1997 and 2001, while supply chain business practices are responsible for triggering declines in the merchant wholesale trade inventory-sales ratio after that period.

Census Bureau reports do not capture cross-sector flows or supply chain linkages. Therefore, we relate goods-handling industries at different stages of a supply chain defining the pharmaceutical supply chain to include the following industries:

- Pharmaceuticals Manufacturing (M3 Category 25B)[13]
- Drugs and Druggists' Sundries Wholesalers (NAICS 4222)
- Health and Personal Care Stores[14] (NAICS 446)

According to data compiled by the Healthcare Distribution Management Association (HDMA), merchant wholesalers are the primary channel by which pharmaceutical manufacturers bring their products to market. Merchant drug wholesaler sales were $260.9 billion in 2003 according to MTIS data. Compound annual sales growth from 1992 through 2003 for NAICS 4222 was 13.1% versus 4.2% for the other 17 industries in the sector. NAICS 4222 accounted for 9.0 percent of all merchant wholesale trade sales in 2003 versus 3.9 percent of total 1992 sales, making it one the largest merchant wholesale industries.

The pharmaceutical supply chain provides a counter-point to the perception that the adoption of information technology in the supply chain correlates to declining inventory-sales ratios. While the merchant wholesale inventory-sales ratio in NAICS 4222 had a statistically significant negative trend from 1992 to 2003 (Exhibit 9), much of the decline appears to have occurred from 1994 to 1997. (See Exhibit 11.) Furthermore, the period from January 1997 to

[13] These data are not publicly available by stage of processing.
[14] Unfortunately, monthly inventory and sales data are not publicly available for NAICS 446, nor are there data for non-store retailers, such as e-tailers and mail order firms, that handle drug sales to household consumers.

December 2001 exhibited a statistically significant increase in the inventory-sales ratio (p=0.005). Average inventory-sales ratios in 2001 were 8 percent higher than in 1997.

INSERT Exhibit 11 ABOUT HERE

In contrast to the experience of wholesalers, the pharmaceutical manufacturing industry had a statistically significant increase in inventory-sales ratios, with much of the increase appearing to occur since 2001. (See Exhibit 12.)

INSERT Exhibit 12 ABOUT HERE

These patterns are unusual given the well-documented adoption and use of technology in the pharmaceutical wholesale industry. Information technology accounted for more than half of all capital expenditures investment and 8% of annual operating expenses at wholesale firms in 2002.[15] The use of technology for product handling is extensive. HDMA reports that more than 90% of products received by wholesalers are bar coded and 17 percent of invoice lines are picked by fully automated methods.

Large efficiency improvements can be traced to the substitution of information technology for human processing and activities in areas such as order management, inventory control, product picking, delivery route scheduling, and warehouse activities (Hill and Swenson 1994, Oswald and Boulton 1995, Fein 1998). In addition, technology systems in the pharmaceutical supply chain need to accommodate complex distribution and handling characteristics such as barcode scanning, chargebacks, temperature control, expiration date control, and product size SKU detail. Thus, there are substantial economic gains from the adoption of product handling technologies such as bar codes, warehouse automation, or electronic inventory linkages with customers (Clemons and Row 1987).

[15] *2003 HDMA Industry Profile and Healthcare Factbook*, Healthcare Distribution Management Association.

Instead of technology per se, the explanation for the time trends in inventory-sales ratios may come from a series of business policy decisions made by wholesalers and manufacturers. We believe that pharmaceutical wholesalers strategically elected to hold additional inventory relative to sales levels because of their technology-enhanced capabilities to forward buy inventories and profit from the product price inflation. However, recent manufacturer-wholesaler business agreements, which are called inventory management agreements (IMAs), explain the reversal of this trend in 2002.

Forward buying, a practice in which a wholesaler purchases excess inventory not tied to near-term demand, represents a supply chain dynamic with an enormous impact on inventory-sales ratios. This technique has been especially profitable in the pharmaceutical wholesaling industry due to the relatively high product price inflation for pharmaceutical products. Expectations of rising price levels create incentives for drug wholesalers to purchase product in advance of demand. These products can then be resold later at the new, higher prices. In many situations, wholesalers buy in anticipation of imminent manufacturer price increases.

The past few years have seen the adoption of Inventory Management Agreements (IMAs). In a basic IMA, the wholesaler agrees to reduce or eliminate forward buying of a manufacturer's products in return for a fee structure or payment from the manufacturer to offset the wholesaler's economic losses from the discontinuation of forward buying. Essentially, manufacturers are paying wholesalers not to speculate with inventory.

The economic significance of the transition away from forward-buying due to IMAs was highlighted in financial disclosures made by Cardinal Health, one of the three largest wholesalers. Due to the adoption of inventory management agreements, Cardinal reported that its product inventories were $500 million lower than expected in the second quarter of 2004.

The company estimated that the reduction in inventory translated into substantial lost income potential because the company has historically earned a 15 to 20 percent return on inventory.[16] Cardinal's profit warning reduced its stock price by nearly 25 percent in one day. McKesson, another large wholesaler, has made similar disclosures.[17]

Exhibit 13 shows the declining inventory-sales ratios for Cardinal Health and McKesson, two of the leading companies in this supply chain.[18] The companies' public disclosures suggest that IMAs have been an important cause of the decline.

INSERT Exhibit 13 ABOUT HERE

Inventory management agreements have also had a significant impact on major pharmaceutical manufacturers. Merck & Co., one of the largest global manufacturers, announced that its 2003 annual sales were reduced by $700 to $750 million due to its new inventory agreements with wholesalers.[19] The company stated that inventory levels at major wholesalers have fallen to between two to three weeks, which would translate into an inventory-sales ratio for its products of less than 0.70 at wholesalers. Other manufacturers, such as Johnson & Johnson, AstraZeneca, Genzyme, and King Pharmaceuticals, have announced similar inventory agreements with wholesalers.

This policy switch in the supply chain occurred shortly after the alleged attempts by Bristol-Myers Squibb to have its wholesalers purchase 56 weeks worth of products at the end of 2001. Subsequent investigations forced Bristol-Myers Squibb to restate its financial records from 1999 through 2002 and officially announce an end to forward buying by wholesalers in March 2003. The company is reported to have signed a settlement agreement with the SEC that

[16] "Cardinal Fee-for-Service Distribution Transition Slows Earnings Growth," *The Pink Sheet*, July 5, 2004.
[17] "Rx Price Restraint Hits McKesson," *The Pink Sheet*, September 13, 2004.
[18] These data were collected from SEC filings made by these companies.
[19] "Merck announces First-Quarter 2004 Earnings Per Share of 73 cents," Merck & Co press release, April 22, 2004.

will "limit future sales to wholesalers based on demand or on amounts that do not exceed approximately one month of inventory on hand."[20] In other words, the proposed SEC settlement legally defines normal inventory levels at wholesalers of Bristol-Myers Squibb's wholesalers to be less than 1.0.

In light of these changes, the increase in the inventory-sales ratio in manufacturing is puzzling. We might expect pharmaceutical manufacturers to hold greater inventories when wholesalers might engage in forward buying due to uncertainty about ordering patterns. A wholesaler could place a large order for its inventory, creating an out of stock risk for the manufacturer if another wholesaler or a direct sales customer placed an order. Lost sales are especially costly for manufacturers since their products have a finite period of marketplace exclusivity. In contrast, inventories at pharmaceutical manufacturers have been trending upward since the introduction of IMAs.

6. Discussion and Conclusion

This paper has provided counterfactual evidence to the widely held belief that information technology adoption has led to declines in the inventory-sales ratio. Less than half of the time series we examined did not experience a consistent decline in the inventory-sales ratio during the past 12 years. Furthermore, many industries illustrated a range of conditions, ranging from no change to increasing ratios.

Our empirical approach was largely atheoretical because we did not explicitly test any formal hypotheses about the factors affecting inventory-sales ratios over time. For instance, we use industry analysis to conclude that time trends in the pharmaceutical industry were the result of technology-enabled profit maximizing behavior by wholesalers who were profiting from product price increases.

[20] "Bristol and SEC Define Normal Inventory Levels as One Month," *The Pink Sheet*, August 9, 2004

Despite the practical significance of forward buying, this profit-maximizing objective is not captured by the two most common economic models of inventory behavior, which focus on either adjustment costs in production/delivery or on fixed costs of ordering by customers (Ramey and West 1997). McCarthy and Zakrajsek (1998) empirically compare these models in wholesale and retail trade, concluding that the latter model provides a better fit to observed patterns in their data set. Nevertheless, models deriving aggregate behavior from microeconomic inventory behavior would benefit from more attention to more complex objective functions.

Similarly, we did not directly evaluate the link between information technology spending and changes in inventory-sales ratios. There is surprisingly little research documenting a specific empirical link between firm-level adoption of supply chain practices and declines in an industry's inventory-sales ratio. Prior research has attempted to correlate general equipment and software costs to declines in inventory-sales ratios (Feroli 2002) or related supply-chain technology spending to inventory levels within a single industry (Abernathy et al 1999).

As a result, we can not conclusively analyze other supply chains with patterns seemingly at odds with the straightforward technology explanation. Consider the food supply chain, where manufacturers have not appreciably reduced inventory-sales levels, despite improvements elsewhere in the supply chain and an abundance of technological innovation in the industry. The inventory-sales ratio for finished goods at upstream suppliers in food manufacturing (11S) did not change, although the overall trend was positive. In contrast, merchant wholesalers of grocery products (NAICS 4224) and retail food and beverage stores (NAICS 445) both experienced statistically significant declines in inventory-sales ratios. These patterns are surprising given the focus on using information technology to share data between trading partners with techniques

such as Efficient Consumer Response (ECR)[21] and Collaborative Planning, Forecasting, and Replenishment.

This research is subject to several additional limitations, one of which is measurement error. As we note above, inventory and sales data are gathered by the U.S. Census Bureau and are subject to both sampling and non-sampling errors. The specific adjustments to these data, such as the application of chain-weighted price indices by the BEA, are not available to outside researchers. Other issues, such as the switch from SIC to NAICS, may also have affected the time series in an indeterminate manner.

Our methodology assumes the meaning of sales did not change during the sample period. However, some companies in wholesale and retail sectors are adding services revenue to their traditional goods-resale sales volume. For example[22], The Home Depot, a large retailer of home improvement products, now generates revenues from installation on select products, including flooring, cabinets, roofing, and appliances through its At-Home Services operation. Cardinal Health, one of the largest wholesalers of pharmaceuticals, generated 5 percent of company revenues and 26 percent of operating earnings from its two services divisions in 2003. One recent study found that over 80 percent of merchant wholesalers plan to offer fee-for-service pricing by 2008 (Fein 2004).

The result of fee-for-service pricing could be a lower inventory-sales ratio even though there has been no increase in goods-handling efficiency at the firm. In other words, inventory-sales ratios would have risen but for a shift to fee-for-service offerings that depressed a merchant wholesale or retail inventory-sales ratio and confounded our analyses.

[21] *Efficient Consumer Response: Enhancing Consumer Value in the Grocery Industry*, Food Marketing Institute, 1993.
[22] Information for these three examples comes from publicly available material about these companies.

Throughout our analysis, we have focused on relative levels of inventory and sales. Future research should evaluate how changes in gross margin – the mark-up above cost of goods sold – influence measurement of inventory-sales ratios in wholesale and retail trade. Gross margin is embedded in the denominator of the inventory-sales ratio because total sales equals cost of goods sold plus gross margin dollars. Thus, the inventory-sales ratio varies inversely with gross margin as a percent of sales. In other words, the inventory-sales ratio could decline if gross margins increase without any genuine change in supply chain efficiency. The converse is also true – declining gross margins lead to increases in the inventory-sales ratio, all else equal.

We are not aware of any studies using MTIS or NIPA data that decompose changes in an industry's inventory-sales ratio into change in inventories, change in sales, and the change in gross margin. One approach would be to follow Ginter and La Londe (2001) and use inventory-to-COGS to eliminate variability due to gross margins and changes or differences in gross margins. The inverse of the inventory-to-COGS ratio is the number of inventory turns in a time period. All else equal, higher inventory turnover figures indicate a faster or more efficient supply chain as products are moving in and out of a warehouse more quickly. However, data availability is more limited with this approach.

The many unanswered questions suggest that there is much still to be learned about the forces changing inventory-sales ratios.

7. Bibliography

Abernathy, F., J. Dunlop, J. Hammond, and D. Weil (1999). *A Stitch in Time: Lean Retailing and the Transformation of Manufacturing*.

Allen, D. (1995), "Changes in Inventory Management and the Business Cycle," *Federal Reserve Board of St. Louis Review*, July/August.

Clemons, E. and M. Row (1987), "McKesson Drug Company: A Case Study of Economost -- A Strategic Information System," *Journal of Management Information Systems*, 5 (1), 36-50.

David, P. (2001), "Productivity Growth Prospects and The New Economy in Historical Perspective," *European Investment Bank Papers*, volume 6, number 1.

Fein, A.J. (1998), "Understanding Evolutionary Processes in Non-Manufacturing Industries: Empirical Insights from the Shakeout in Pharmaceutical Wholesaling," *Journal of Evolutionary Economics*, Fall.

Fein, A.J. (2004). *Facing the Forces of Change: The Road to Opportunity*. Washington, DC: National Association of Wholesaler-Distributors.

Ferguson, R. W. (2001), "Domestic Macroeconomic Developments: Past, Present, and Future," Remarks at the Bay Area Council 2001 Outlook Conference. (Accessed at *http://www.federalreserve.gov/boarddocs/speeches/2001/20010112/* on June 13, 2004.)

Feroli, M. (2002), "An Equilibrium Model of Inventories with Investment-Specific Technical Change," New York University working paper.

Filardo, A. (1995), "Recent Evidence on the Muted Inventory Cycle," *Federal Reserve Board of Kansas City Economic Review,* Second Quarter.

Ginter, J.L. and B.J. La Londe. (2001), "An Historical Analysis of Inventory Levels: An Exploratory Study," Ohio State University working paper.

Greenspan, Alan. (1999). "Maintaining Economic Vitality," Federal Reserve Board, Remarks in Millennium Lecture Series.

Hill, N. C. and M. J. Swenson (1994). "The Impact of Electronic Data Interchange on the Sales Function," *Journal of Personal Selling & Sales Management*, 14 (3).

Kahn, J. and M. McConnell (2002), "Has Inventory Volatility Returned? A Look at the Current Cycle," *Current Issues in Economics and Finance*, Federal Reserve Bank of New York.

Kahn, J., M. McConnell and G. Perez-Quiroz (2001), "Inventories and the Information Revolution: Implications for Output Volatility," Federal Reserve Bank of New York working paper.

Kahn, J., M. McConnell and G. Perez-Quiroz (2002), "On the Causes of Increased Stability of the US Economy," *Economic Policy Review*, Federal Reserve Bank of New York.

Krane, S. (2002), "Commentary," *Federal Reserve Bank of New York Economic Policy Review*, May.

MacKinnon, J. G. (1991), "Critical Values for Cointegration Tests," in *Long-Run Economic Relationships: Readings in Cointegration*, Engle, R. F. and C. W. J. Granger, eds. New York: Oxford University Press.

McCarthy, J. and E. Zakrajsek (1998), "Trade Inventories," *Staff Reports*, Federal Reserve Bank of New York, Number 53.

McCarthy, J. and E. Zakrajsek (2002), "Inventory Dynamics and Business Cycles: What has changed?" Federal Reserve Bank of New York working paper.

McConnell, M., P. Mosser, G. Perez Quiroz (1999), "A Decomposition of the Increased Stability of GDP Growth," *Current Issues in Economics and Finance*, Federal Reserve Bank of New York.

McConnell, M. and G. Perez Quiroz (2000), "Output Fluctuations in the US: What has changed Since the Early 1980's?" Federal Reserve Board of New York working paper, February

Mesenbourg, T. L. (1999), "Measuring E-Business: Challenges and Priorities," Bureau of the Census, U.S. Department of Commerce.

Oswald, S. And W. R. Boulton (1995), "Obtaining Industry Control: The Case of the Pharmaceutical Distribution Industry," *California Management Review*, 38 (1).

Ramey, V.A. and K. D. West (1997), "Inventories," in *Handbook of Macroeconomics*.

Ramey, V.A. and D.J. Vine (2004), "Why Do Real and Nominal Inventory-Sales Ratios Have Different Trends?" *Journal of Money, Credit and Banking*, forthcoming.

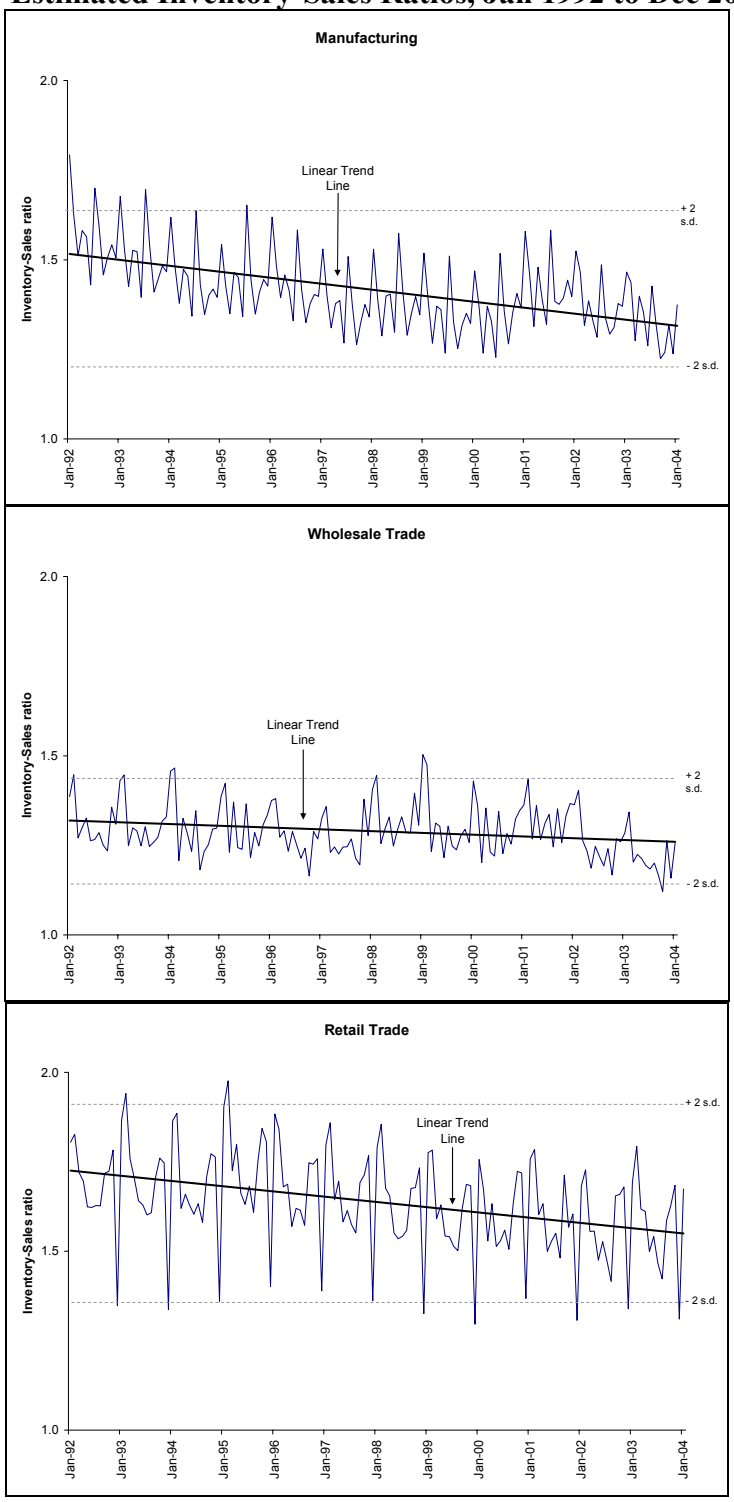
Steindel, C. (1999), "Statement to the US Senate Special Committee on the Year 2000 Technology Problem."

Stalk, G, Jr., P. Evans and L. E. Shulman (1992), "Competing on Capabilities: The New Rules of Corporate Strategy," *Harvard Business Review*, March/April.

Stock, J. and M. Watson (2002). "Has the Business Cycle Changed and Why?" NBER Working Paper.

Willis, J. (2003), "Implications of Structural Changes in the US Economy for Pricing Behavior and Inflation Dynamics," *Federal Reserve Board of Kansas City Economic Review*, First Quarter.

Exhibit 1: Estimated Inventory-Sales Ratios, Jan 1992 to Dec 2003



Source: U.S. Census Bureau, Manufacturing and Trade Inventories and Sales, not adjusted for seasonal variations or trading-day differences.

Exhibit 2: Summary of Available Data

Sector	Source	Level of Analysis	Available Industries
Manufacturing	Manufacturers' Shipments, Inventories, and Orders Survey	2 digit M3 Industry Groupings	21
Retail Trade	Monthly Retail Trade Survey	3 digit NAICS industry	6
Wholesale Trade (merchant only)	Monthly Wholesale Trade Survey	4 digit NAICS industry	18

Exhibit 3: Overall Summary of Results

	Overall Trend (a)		Significant Trends (p<0.05) (b)				
	Positive	Negative	Positive	Negative	No Change (c)	Average Est. Slope (x100)	S.E. of Est. Slope
Manufacturing							
Materials & Supplies	5	16	2	10	9	-0.055	0.075
Work in Progress	3	18	1	13	7	-0.069	0.111
Finished Goods	14	7	5	4	12	0.014	0.083
Merchant Wholesale Trade	6	12	4	9	5	-0.049	0.158
Retail Trade	1	5	0	5	1	-0.218	0.239
Totals	29	58	12	41	34		
	33%	*67%*	*14%*	*47%*	*39%*		

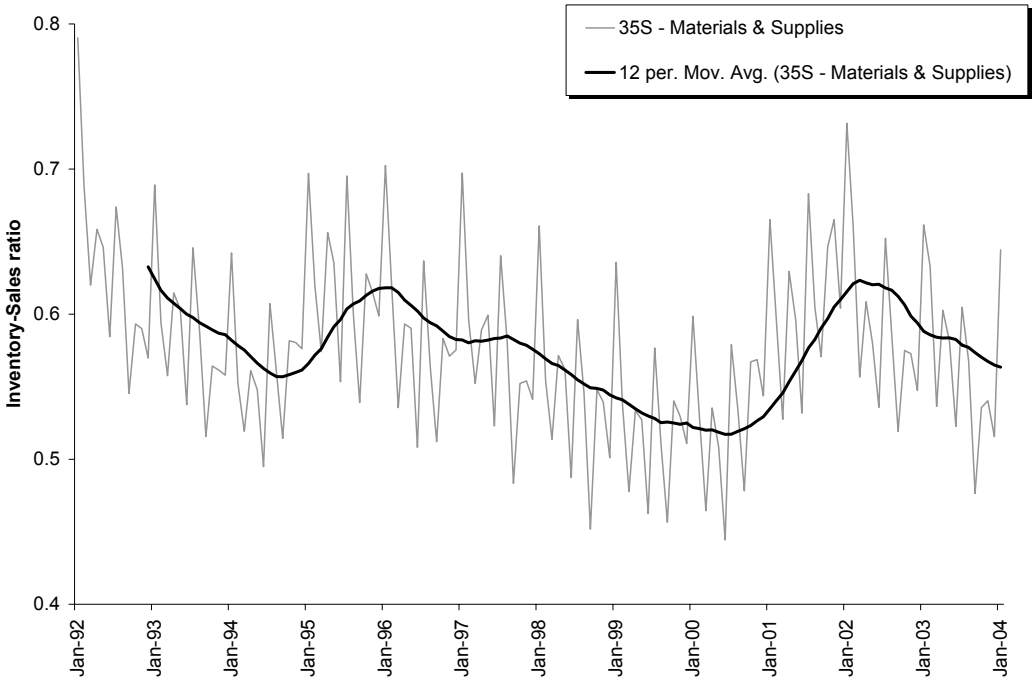
(a) Overall Trend based on the sign of the estimated slope from a linear regression of each inventory-sales ratio time series on a linear time trend. See text for details.
(b) Significance of trend determined by sequential testing strategy described in text.
(c) Time series without a statistically significant trend were classified as "No Change."

Exhibit 4: Manufacturing Inventory-Sales Ratios for Materials and Supplies, Summary by M3 category

M3 category	Description	12 year Trend*	1992 average	2003 average	% change, 1992 - 2003 (b)
11S	Food Products	Negative	0.31	0.27	-11%
12S	Beverage & Tobacco Products	Negative	0.90	0.63	-30%
13S	Textiles	Positive	0.42	0.44	3%
14S	Textile Products	No Change	0.63	0.60	-5%
15S	Apparel	No Change	0.54	0.39	-28%
16S	Leather & Allied Products	No Change	0.63	0.48	-24%
21S	Wood Products	Negative	0.59	0.47	-21%
22S	Paper Products	Negative	0.65	0.52	-20%
23S	Printing	Negative	0.47	0.35	-25%
24S	Petroleum & Coal Products	Negative	0.27	0.22	-18%
25S	Basic Chemicals	No Change	0.46	0.44	-5%
26S	Plastics & Rubber Products	No Change	0.51	0.47	-6%
27S	Nonmetallic Mineral Products	No Change	0.48	0.46	-3%
31S	Primary Metals	Positive	0.54	0.56	2%
32S	Fabricated Metal Products	Negative	0.59	0.55	-8%
33S	Machinery	No Change	0.69	0.61	-12%
34S	Computer & Electronic Products	No Change	0.56	0.51	-9%
35S	Electronic Equipment, Appliances and Components	No Change	0.63	0.56	-11%
36S	Transportation Equipment	Negative	0.42	0.34	-21%
37S	Furniture & Related Products	Negative	0.70	0.56	-20%
39S	Miscellaneous Products	Negative	0.73	0.57	-21%

(a) Significance of trend determined by sequential testing strategy described in text..
(b) Percentage change in annual values from 1992 through 2003.

Exhibit 5: Inventory-Sales Ratio and 12 month moving average, Electronic Equipment, Appliances and Components (M3 35S), Materials and Supplies only



Source: U.S. Census Bureau, Manufacturers' Shipments, Inventories, and Orders Survey, not adjusted for seasonal variations or trading-day differences.

Exhibit 6: Manufacturing Inventory-Sales Ratios for Work-in-Progress, Summary by M3 category

M3 category	Description	12 year Trend*	1992 average	2003 average	% change, 1992 - 2003 (b)
11S	Food Products	No Change	0.07	0.08	8%
12S	Beverage & Tobacco Products	Positive	0.25	0.52	106%
13S	Textiles	Negative	0.43	0.39	-10%
14S	Textile Products	Negative	0.29	0.24	-15%
15S	Apparel	No Change	0.35	0.29	-18%
16S	Leather & Allied Products	Negative	0.45	0.19	-58%
21S	Wood Products	No Change	0.25	0.26	2%
22S	Paper Products	No Change	0.12	0.09	-29%
23S	Printing	Negative	0.29	0.22	-24%
24S	Petroleum & Coal Products	No Change	0.22	0.22	-4%
25S	Basic Chemicals	No Change	0.24	0.28	16%
26S	Plastics & Rubber Products	Negative	0.19	0.16	-16%
27S	Nonmetallic Mineral Products	Negative	0.22	0.17	-23%
31S	Primary Metals	Negative	0.67	0.56	-17%
32S	Fabricated Metal Products	Negative	0.64	0.46	-28%
33S	Machinery	Negative	0.88	0.68	-23%
34S	Computer & Electronic Products	No Change	1.01	0.54	-47%
35S	Electronic Equipment, Appliances and Components	Negative	0.51	0.35	-32%
36S	Transportation Equipment	Negative	1.22	0.74	-39%
37S	Furniture & Related Products	Negative	0.33	0.27	-19%
39S	Miscellaneous Products	Negative	0.46	0.30	-35%

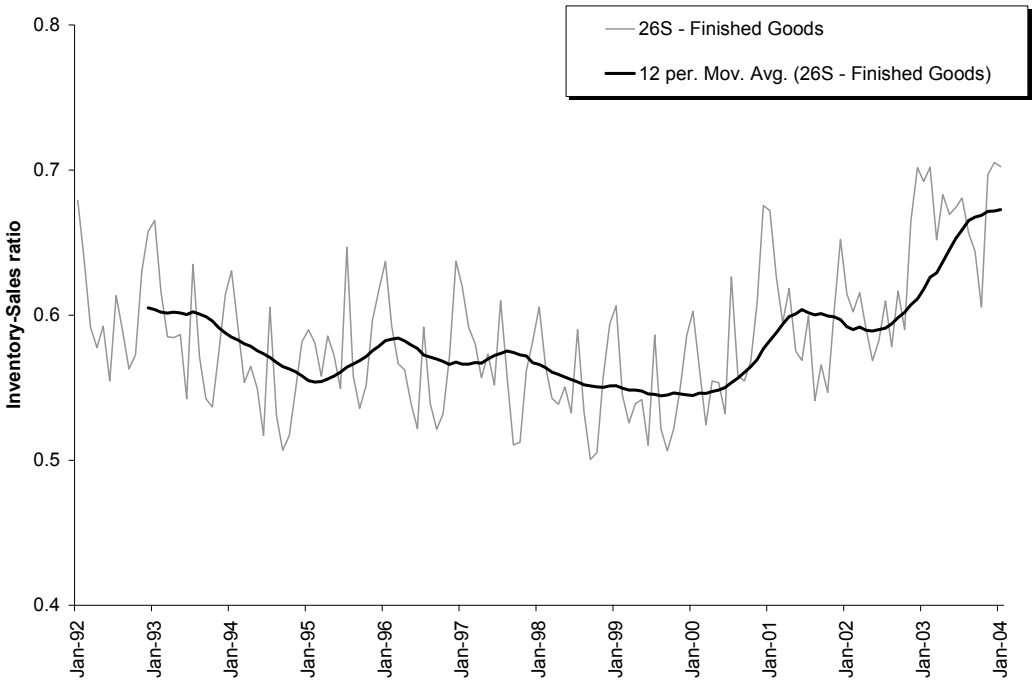
(a) Significance of trend determined by sequential testing strategy described in text..
(b) Percentage change in annual values from 1992 through 2003.

Exhibit 7: Manufacturing Inventory-Sales Ratios for Finished Goods, Summary by M3 category

M3 category	Description	12 year Trend*	1992 average	2003 average	% change, 1992 - 2003 (b)
11S	Food Products	No Change	0.49	0.51	4%
12S	Beverage & Tobacco Products	No Change	0.54	0.52	-3%
13S	Textiles	Positive	0.59	0.71	20%
14S	Textile Products	Positive	0.76	0.88	15%
15S	Apparel	Positive	0.73	0.97	33%
16S	Leather & Allied Products	Positive	0.90	1.17	30%
21S	Wood Products	Positive	0.48	0.52	8%
22S	Paper Products	No Change	0.51	0.51	0%
23S	Printing	Negative	0.23	0.22	-6%
24S	Petroleum & Coal Products	No Change	0.41	0.33	-20%
25S	Basic Chemicals	No Change	0.68	0.65	-3%
26S	Plastics & Rubber Products	No Change	0.61	0.67	11%
27S	Nonmetallic Mineral Products	No Change	0.87	0.70	-19%
31S	Primary Metals	No Change	0.54	0.55	2%
32S	Fabricated Metal Products	Negative	0.61	0.53	-13%
33S	Machinery	No Change	0.75	0.71	-6%
34S	Computer & Electronic Products	No Change	0.42	0.37	-12%
35S	Electronic Equipment, Appliances and Components	Negative	0.72	0.57	-21%
36S	Transportation Equipment	No Change	0.27	0.25	-5%
37S	Furniture & Related Products	Negative	0.58	0.51	-12%
39S	Miscellaneous Products	No Change	0.90	0.86	-4%

(a) Significance of trend determined by sequential testing strategy described in text..
(b) Percentage change in annual values from 1992 through 2003.

Exhibit 8: Inventory-Sales Ratio and 12 month moving average, Plastics and Rubber Products (M3 26S), Finished Goods



Source: U.S. Census Bureau, Manufacturers' Shipments, Inventories, and Orders Survey, not adjusted for seasonal variations or trading-day differences.

Exhibit 9: Merchant Wholesale Trade Inventory-Sales Ratios, Summary by 4-digit NAICS Industry

NAICS	Description	12 year Trend (a)	1992 average	2003 average	% change, 1992 - 2003 (b)
4211	Motor Vehicles & Parts and Supplies	Negative	1.64	1.37	-16%
4212	Furniture & Home Furnishings	Negative	1.71	1.50	-12%
4213	Lumber & Other Construction Materials	Negative	1.26	1.07	-15%
4214	Professional & Commercial Equipment and Supplies	Negative	1.49	1.15	-23%
4215	Metals and Minerals	Positive	1.60	1.81	13%
4216	Electrical Goods	Negative	1.69	1.27	-25%
4217	Hardware, Plumbing, Heating Equipment and Supplies	No Change	1.92	1.88	-2%
4218	Machinery, Equipment and Supplies	Positive	2.23	2.37	7%
4219	Miscellaneous Durables	Positive	1.36	1.48	9%
4221	Paper & Paper Products	No Change	1.10	1.00	-10%
4222	Drugs and Druggist Sundries	Negative	1.55	1.43	-8%
4223	Apparel	Negative	1.99	1.73	-13%
4224	Groceries and Related Products	Negative	0.77	0.63	-18%
4225	Farm Product Raw Materials	Positive	0.90	1.01	13%
4226	Chemicals & Allied Products	No Change	1.12	1.14	2%
4227	Petroleum & Petroleum Products	No Change	0.35	0.25	-30%
4228	Beer, Wine & Alcoholic Beverages	No Change	1.13	1.09	-4%
4229	Miscellaneous Nondurables	Negative	1.19	1.13	-5%

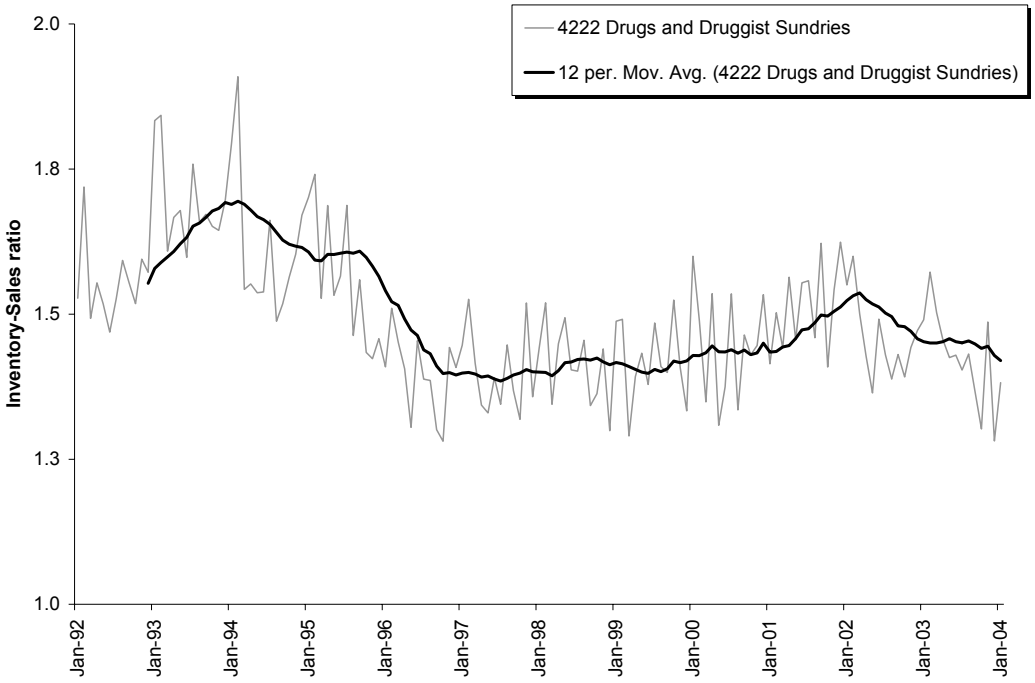
(a) Significance of trend determined by sequential testing strategy described in text..
(b) Percentage change in annual values from 1992 through 2003.

Exhibit 10: Retail Trade Inventory-Sales Ratios, Summary by 3-digit NAICS Industry

NAICS	Description	12 year Trend*	1992 average	2003 average	% change, 1992 - 2003 (b)
441	Motor Vehicles & Parts Dealers	No Change	1.90	2.00	5%
442, 443	Furniture, Home Furnishing, Electronics & Appliance Stores	Negative	1.90	1.65	-13%
444	Building Material, Garden Equipment and Supplies Dealers	Negative	1.86	1.72	-7%
445	Food & Beverage Stores	Negative	0.88	0.82	-7%
448	Clothing & Clothing Accessory Stores	Negative	2.73	2.62	-4%
452	General Merchandise Stores	Negative	2.45	1.74	-29%

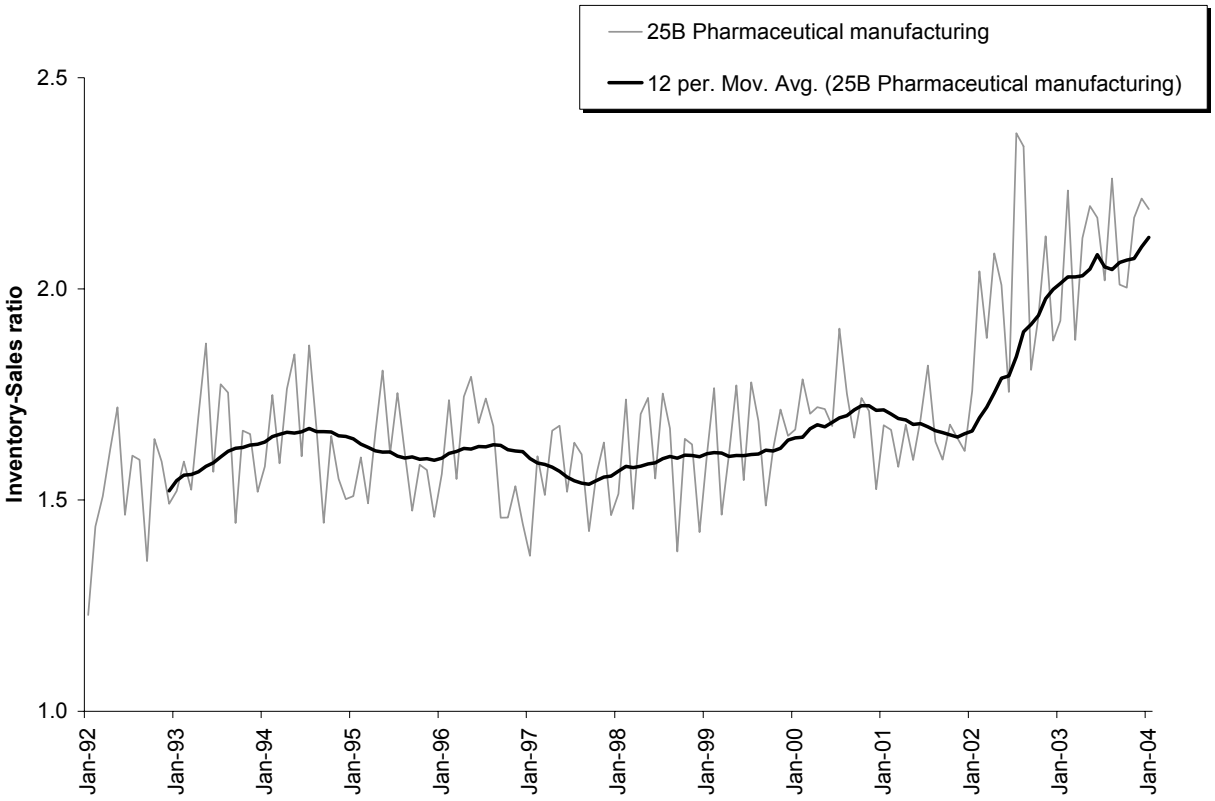
(a) Significance of trend determined by sequential testing strategy described in text..
(b) Percentage change in annual values from 1992 through 2003.

Exhibit 11: Inventory-Sales Ratio and 12 month moving average, Merchant Wholesale Trade, Drugs and Druggist Sundries (NAICS 4222)



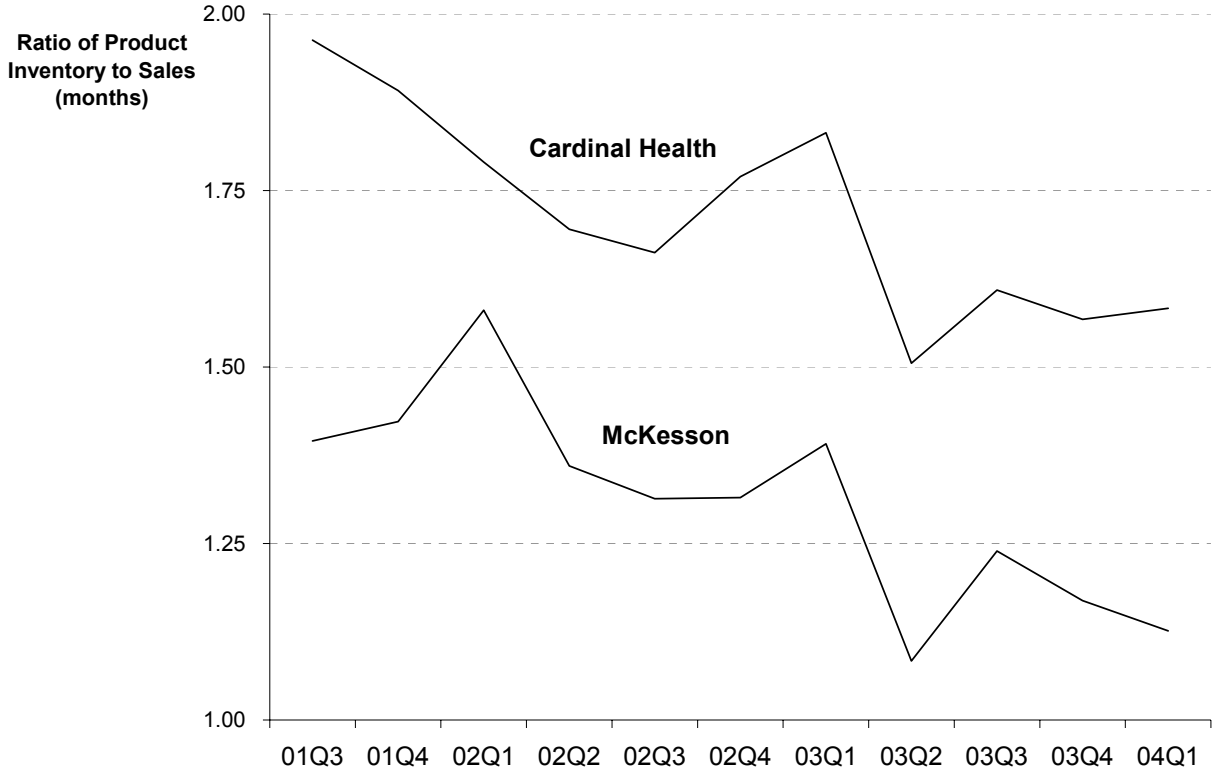
Source: U.S. Census Bureau, Monthly Wholesale Trade Survey, not adjusted for seasonal variations or trading-day differences.

Exhibit 12: Inventory-Sales Ratio and 12 month moving average, Pharmaceutical Manufacturing (M3 25B)



Source: U.S. Census Bureau, Manufacturers' Shipments, Inventories, and Orders Survey, not adjusted for seasonal variations or trading-day differences.

Exhibit 13: Inventory-sales Ratios at Pharmaceutical Wholesalers



Source: Pembroke Consulting analysis of corporate 10Q/10K SEC