Inventory Write-downs, Sales Growth, and Ordering Policy: An Empirical Investigation

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Abstract

If the market value of inventory declines below its original cost, for reasons such as damage or obsolescence, under U.S. Generally Accepted Accounting Principles a company should write it down to the new market value and recognize a loss. This paper uses publicly available data to conduct an empirical investigation of 290 firms, which experienced a first-time inventory write-down of more than 1% of average total assets between the years 2002 and 2004. The average inventory write-down in our sample is $13.2 million, which represents 3.7% of a firm’s average total assets. We show that these write-downs are associated with a severe negative impact on firms’ operating performance: The mean firm in our sample experiences a -15.4% return on assets in the year of an inventory write-down and a -21.6% market-adjusted return. We also examine the relationships between sales growth, purchasing policies, and inventory write-downs. Empirical evidence suggests that extreme sales growth firms are significantly more likely to experience a future inventory write-down than moderately growing firms. We find that, on average, all growing firms purchase more inventory than they sell, i.e., responding to growth, they tend to build up stock. The extreme sales growth firms, however, purchase less inventory than their moderately growing counterparts, indicating that these firms may be aware of the heightened risk of write-downs, which thus far has not been explicitly considered in the inventory literature. In addition, we find that extreme sales growth firms with write-downs build up more stock than extreme sales growth firms without write-downs. However, we do not find evidence of exuberant inventory purchases among these firms: In fact, inventory policy of an average extreme growth firm with write-downs is statistically indistinguishable from that of a firm experiencing only moderate or no sales growth. Future research may explore whether inventory policies used by moderately growing firms are inappropriate for extreme growth firms. This may lead to useful heuristics that would function well in a non-stationary demand environment with stochastic holding cost.

Key words: inventory; write-downs; obsolescence; sales growth; ordering policy

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1 Introduction

According to the U.S. Federal Reserve, in September 2010, the total value of manufacturing and trade inventories reached $1.4 trillion dollars\(^1\). On average, inventory represents approximately 15\% of total firm assets for public U.S. firms\(^2\). Because such a significant fraction of firms’ assets are invested in inventories, managing them is important and there is empirical evidence that companies continuously seek to improve their inventory management processes and to reduce inventory levels: for example, between 1992 and 2010, the average inventory to sales ratio has steadily declined from 1.56 to 1.27\(^3\).

The central concern in inventory management is to find the right trade-off between the cost of holding inventory and the cost of shortages. Since managing these costs commonly depends on the demand pattern, such an issue is significantly more complicated when demand is stochastic and its distribution changes over time. Wagner (2002, p.224) observes “...most demand environments change over time, usually gradually but sometimes abruptly ...”; Graves (1999, p.50) attributes this phenomenon to increasingly shorter life cycles of products that cause demand to become non-stationary.

Frequently, in cases when demand is stochastic and non-stationary (e.g., due to growth or seasonality), little can be said about an optimal inventory policy and managers must rely on approximations, heuristics, or base-stock models with appropriate “fudge factors,” designed to balance conflicting pressures\(^4\). Pressures for high inventories include reduction of backorders and stockouts (Zipkin, 2000, §6), institutional reasons that lead rational inventory managers to amplify growth in demand (Gilbert, 2005; Kahn, 1987), and shortage gaming, known to occur when distributors are perceived to ration supply (Lee et al., 1997). Reasons for low inventories include high holding cost and risk of incurring obsolescence cost (Song and Zipkin, 1993, 1996).

The primary contributor to obsolescence costs, one the theoretical inventory literature has largely not considered, are inventory write-downs. Under U.S. Generally Accepted Accounting Principles (GAAP), inventories are recorded at cost. However, if the market value of inventory declines below its original cost, for reasons such as damage or obsolescence, a company must write down the inventory to the new market value to recognize this loss. Best Buy’s financial statements, for example, include the following disclosure: “...merchandise inventories are recorded at the lower of average cost or market. ...” Any inventory write-down must be reflected as an expense (part of cost of goods sold) on the income statement. Thus, if the value of inventory declines, a company incurs a financial loss. These costs can be significant: For example, there is the well-publicized $2.25 billion inventory write-down at Cisco Systems, which led to a decline in the company’s market value

\(^1\)See Inventories: Total Business (BUSINV) at http://research.stlouisfed.org/fred2/series/BUSINV
\(^2\)This value is computed for the firms in the intersection of the COMPUSTAT annual and CRSP files for all non-financial and non-utility firms over the 1980-2008 period.
\(^3\)See Inventory to Sales Ratio: Total Business (ISRATIO) at http://research.stlouisfed.org/fred2/series/ISRATIO
\(^4\)For example, under a widely-used inventory heuristic, the base-stock inventory level moves in parallel with the mean lead-time demand (Zipkin, 2000, §9.2.2). The heuristic performs well if the demand distribution changes slowly, but leads to inventory shortages (or excesses) if the distribution changes suddenly.
from $430 billion in March of 2000 to $108 billion in March of 2001; more recently, the digital video
recorder (DVR) supplier TiVo posted a net loss of $17.7 million in its fiscal second quarter of 2007,
which the company accredited to an inventory write-down.

Despite its prevalence and potential significant impact, there is a lack of research empirically
investigating inventory write-downs in the literature. Many important questions remain open and
could be addressed by empirical analysis. For example, how do inventory write-downs affect firms’
operating performance? Is there any link between write-downs and demand growth? If yes, how do
firms manage inventory when facing growing demand and inventory write-down risks (e.g., is their
behavior consistent with the theoretical predictions)? What is the relationship between inventory
write-downs and firms’ inventory purchasing policies?

To shed some light on the above questions, we use publicly available data to conduct a descrip-
tive investigation of inventory write-downs. Using results from existing analytical inventory and
accounting literatures, we propose several hypotheses that relate sales growth, inventory purchases,
and inventory write-downs. We then test these relationships based on a sample of 290 firms experi-
encing a first-time inventory write-down of more than 1% of average total assets between calendar
years 2002 and 2004.

We report four main findings. First, we provide large sample descriptive statistics of the mag-
nitude and impact of inventory write-downs. We document an average inventory write-down in our
sample of $13.2 million representing 3.7% of a firm’s average total assets. We find that the financial
consequences of these write-downs are severe. Firms experiencing write-downs have a -15.4% return
on assets and a -21.5% market-adjusted return in the period of the write-down.

Second, using sales data as a proxy for unobservable demand data, we establish a link be-
tween firms’ sales growth and inventory write-downs. Empirical evidence suggests that firms with
high sales growth are more likely to experience a subsequent inventory write-down. This leads
us to conjecture that high sales growth is more prone to slowdown, which has been confirmed in
our analysis. Therefore, it appears that firms experience write-downs not only due to exuberant
inventory purchases, but also due to exogenous factors, which include non-stationary demand.

Third, to learn how firms manage inventory, we investigate how much of their sold inventory
firms replace under growing demand. For comparison, firms are sorted into quintiles based on
their sales growth rate: firms falling in the first quintile (i.e., the top 20%) are referred to as
extreme growth firms while firms in the middle quintiles (i.e., the middle 60%) are defined as
moderate growth firms. We find that firms experiencing no sales growth replace approximately
100% of inventory sold during a period. This corroborates predictions from the inventory theory:
Under stationary demand, firms should use policies (e.g., base-stock or \( r, Q \) policy, depending on
the presence of fixed costs) that simply replace any sold stock. When there is moderate growth,
firms purchase an additional 11.8% of sales growth, i.e., firms experiencing sales growth purchase
more and carry more ending inventories than without growth. Interestingly, however, extreme
sales growth firms replace less of their sold inventory than their moderate growth counterparts,
i.e., extreme growth firms exhibit a more conservative ordering behavior than moderately growing
firms. There has been no consensus so far in the theoretical literature whether fast growth should lead to more aggressive inventory policies (there are arguments for both directions). Our empirical analysis suggests a non-monotone relationship between sales growth and sales adjusted inventory purchases, i.e., it not necessarily true that faster growing firms stock up more to meet demand in the next selling season.

Fourth, we examine whether there is a positive correlation between inventory write-downs and firms’ purchasing policy. This is done by comparing the ordering behavior of firms that experience write-downs to those that do not. We find that the extreme growth firms, which experience write-downs replace more of their sold inventory than other extreme growth firms. However, we do not find evidence of excessive inventory buildup. In fact, average extreme growth firms, which experience write-downs, replace approximately the same amount of sold inventory as moderate growth firms replace. Future research may explore whether this finding implies that inventory policies used by moderately growing firms are inappropriate for extreme growth firms. This may lead to useful heuristics that would function well in a non-stationary demand environment with stochastic holding cost. To our knowledge, the theoretical literature has not considered this issue.

The rest of the paper is organized as follows. Section 2 surveys the related literature. Section 3 summarizes the data, defines the variables used and summarizes the economic impact of inventory write-downs observed in our data set. Section 4 develops our hypotheses. In Section 5, we discuss the empirical methodology we employ. We present our empirical results in Section 6. In the remainder of the paper, we conclude with managerial implications and a discussion of directions for future research.

2 Literature Review

This paper is closely related to the growing empirical literature that aims to link firms’ inventory/supply chain management practices to their financial performance. Hendricks and Singhal (2005b,a) examine the impact of supply chain glitches on firms’ operating performance. It has been shown that these glitches have a significant and long-lasting impact on various operating performance metrics. Singhal (2005); Hendricks and Singhal (2009) document the negative effect of holding excessive inventories on stock price. They find that not all excess inventory announcements are treated equally by the market: The market reaction is less negative for excess inventory announcements made by larger firms, but is more negative for firms with higher growth prospects and with higher debt-equity ratios. Chen et al. (2005) examine the trend of inventories held by American companies and find that abnormally high stock levels are associated with poor long-term stock returns. Rumyantsev and Netessine (2007a) study whether a firm should use lean or responsive inventory policies. They report that mismatched changes in sales and inventory are associated with lower profitability. Kesavan and Mani (2010) test the predictive power of abnormal inventory growth at retail firms. They find that abnormal inventory growth is useful in forecasting retailers’ future earnings; however, both managers and analysts tend to overlook the information conveyed
by such a metric. Our paper contributes to this literature by investigating the impact of inventory write-downs on firms’ operating performance.

This paper is also related to the studies that empirically compare inventory levels across firms/industries/time. Rajagopalan and Malhotra (2001) study the trends of three types of inventories in the U.S. manufacturing industry during the period 1961-1994: materials, work-in-progress, and finished goods. Their analysis suggests that the results from various inventory-reduction efforts are encouraging but also somewhat mixed during this period. Several papers attempt to explain why firms differ in their inventory levels or key performance measures such as inventory turnover. Lai (2006) studies how the stock market affects firms’ inventory decisions. He identifies strong statistical evidence that firms decrease inventory when the market discounts high-inventory firms. Cachon and Olivares (2010) examine the drivers of finished goods inventory in the U.S. automobile industry. It has been found that the difference in finished goods inventory at the major manufacturers can be largely explained by two factors: the number of dealerships in the firm’s distribution network and the firm’s production flexibility. Gaur et al. (2005) and Gaur and Kesavan (2007) develop empirical models to study the correlation between inventory turnover and firm characteristics such as gross margin, size, and sales growth. They find that inventory turnover increases with sales growth, and the rate of the increase depends on firm size and the sign of the sales growth. Rumyantsev and Netessine (2007b) use U.S. company data to test whether the insights offered by classical inventory theory hold at firm levels. They show that firms facing uncertain demand, long lead times, and high gross margin tend to hold more inventory, and larger companies hold less inventories than smaller ones because of the economies of scale effect. Cachon and Olivares (2009) study the effect of competition on retail stock levels by using the data collected from General Motors’ dealerships. The results suggest that dealers carry more inventory when they face intense retail competition (i.e., competition drives the retailers to offer higher service levels). In this paper, we establish the link between high sales growth and the likelihood of inventory write-downs, which is new in the literature. Also we study the association between firms’ ordering behavior and inventory write-downs by examining inventory changes relative to sales growth over time. For an overview of empirical research in operations management the precedes the above papers, we refer the reader to an excellent survey by Roth (2007).

There is an enormous theoretical literature on inventory management. The emphasis of this literature is on analysis of various model settings and characterization of optimal (or near-optimal) ordering policies. Readers are referred to Zipkin (2000) and Porteus (2002) for comprehensive reviews of these inventory models. The extant theoretical inventory literature does not explicitly consider inventory write-downs. It does, however, consider closely related issue of inventory obsolescence and conjectures that its financial impact may be significant (Song and Zipkin, 1993, 1996).

Finally, researchers in accounting have spent considerable time examining issues associated with inventory accounting. Primarily this literature has focused on the determinants and consequences of firms’ accounting choice between LIFO and FIFO costing methods (for a review of
this literature, see Derstine and Huefner, 1974; Dopuch and Pincus, 1988; Niehaus, 1989; Fields et al., 2001). Despite considerable research examining inventory, very little research has examined the link between demand, purchasing policies and inventory write-downs. Despite this dearth of research in accounting a few studies are of note. Francis et al. (1996) provides evidence on the causes and shareholder wealth effects of asset write-downs. Although the focus of the research is on discretionary asset write-offs, which exclude inventory write-downs, they provide strong descriptive evidence that inventory write-downs are large in magnitude and are associated with significant decreases in shareholder wealth. Chen et al. (2010) investigate inventory write-downs using empirical data in the semiconductor industry, but their focus is on managers’ incentives when deciding the timing and magnitude of inventory write-downs. In a more recent study Allen et al. (2010) examine a hand collected sample of inventory write-downs in the context of the accrual anomaly (Sloan, 1996; Thomas and Zhang, 2002). They find that firms with extreme reversals in inventory from high to low (low to high) experience significantly negative (positive) earnings and size-adjusted returns. Using a sample of inventory write-downs they document that reversals in inventory from high to low are extremely overrepresented by firms experiencing inventory write-downs. They also document that inventory write-downs negatively signed are negatively associated with changes in prior periods inventory. They argue that inventory write-downs and the accrual anomaly result from inventors’ lack of understanding that extreme accruals are associated with reversals in accruals resulting from accrual estimation error. They point out that these errors can result from several factors including vagaries of Generally Accepted Accounting Principles (Penman and Zhang, 2002), demand shifts (Thomas and Zhang, 2002), earnings management (Xie, 2001) and over-investment by high growth firms (Titman et al., 2009). Although there are many potential explanations for write-downs, we complement and extend Allen et al. (2010) by more closely examining two possible explanations: demand shifts and inventory investment decisions.

3 Data Description and Definition of Variables

We examine two primary data samples in our analysis. Our first large sample consists of data from the COMPUSTAT fundamentals annual file spanning the years 1980-2008. Stock return data for both samples are obtained from the CRSP monthly returns files. As in prior literature examining changes in inventory, we eliminate all financial services companies (SIC 6000-6999) and utilities (SIC 4900-4999). We also limit the sample to domestic firms (popsrc = D and fic = USA) traded on the NYSE, NASDAQ or AMEX. Our inventory write-down sample uses write-down data that is hand collected from 10-K filings in conjunction with data from the COMPUSTAT fundamentals annual file. The size of our write-down sample is restricted by the cost of hand collecting data and is thus limited to the calendar years 2002-2004. More detailed description is given below.

The financial variables of interest in this study are changes in sales ($\Delta SALES$) and purchases scaled by cost of goods sold ($PURCHASES/COGS$). Purchases is calculated as cost of goods sold plus ending inventory minus beginning inventory. We measure change in sales as percentage
year-over-year changes. We require the availability of COMPUSTAT data for each of the variables for periods $t$ and change in sales for periods $(t-1)$ and $(t+1)$. Because our interest is in examining firms’ ordering policy with respect to inventory, we also eliminate firms with insignificant inventory levels, less than 1% of average total assets. Our final large sample consists of 87,295 firm-year observations from 1980-2008.

We hand collect our inventory write-down data from firms’ 10-K filings. We searched all 10-K filings on the DirectEdgar database during the calendar years 2001-2004. We began by conducting a keyword search for any occurrence of the word write within ten words of the word inventory. We then filtered these results using the CIK numbers of all firms that appeared in both the CRSP and COMPUSTAT databases for the years 2001-2004 and were traded on a major US exchange. After filtering we were left with 5,638 filings. We then searched and read through each 10-K for discussion or documentation of an inventory write-down during the fiscal year. Upon finding evidence of an inventory write-down, we collected the inventory write-down amount from the annual report. Our search yielded many inventory write-downs that were insignificant in magnitude and serial in frequency. As a result we chose to limit our inventory write-down sample to write-downs equal to or larger than 1% of average total assets. In addition, because we empirically observe that many firms take subsequent inventory write-downs following a first large write-down, we limit our sample to the first significant inventory write-down in our sample. We do this because there is reason to suspect that managers are slow in making inventory write-down decisions (Allen et al., 2010). Additionally, the serial frequency, one large write-down followed by another more moderate but significant write-down, is consistent with managers not fully writing down inventory in the first accounting period but opting to write down inventory enough to satisfy auditors in hopes that the inventory value recovers. This would mean that the same events that led to the first inventory write-down such as a negative economic shock or poor inventory management are likely to be the same reasons for observing both the first and second write-downs. Because we are interested in the economic conditions leading to the obsolescence of the inventory and not necessarily the accounting decision to write-down the inventory, we choose to focus our attention on the circumstances prior to the very first inventory write-down. Because we collect data beginning in 2001 and are thus unaware of whether a firm experiences an inventory write-down in 2000, we limit our inventory write-down sample to 2002-2004. Our sample of first time significant inventory write-down firms

5The serial, insignificant write-downs are the result of some firms with routine estimable inventory obsolescence using the indirect or allowance method to account for inventory. Under this method, managers estimate the expected amount of current inventory that will spoil or go obsolete in the next accounting period and expense that amount immediately to a reserve account. As the obsolete inventory is identified, rather than expensing it to the income statement, the inventory is charged to the reserve account. These amounts appear to be small in magnitude and low in variance.

6If we had a longer time-series, we would not necessarily need to focus on only the very first inventory write-down in our sample. We could attempt to identify inventory write-down “episodes.” For example, we might observe two years of significant inventory write-downs followed by three years without a write-down followed by another inventory write-down. Under this scenario, one potential research design would be to identify two different inventory write-down observations, the first two years being one observation and the last year being another. Because our time-series is short and data collection is quite costly, we focus on only the first write-down a firm experiences in our sample window.

7
with available data consists of 290 firm observations. For some of our analysis we merge this write-down sample with the subset of observation in our larger 1980-2008 sample in the calendar years 2002-2004 to obtain a sample of firms experiencing first-time inventory write-downs and firms not experiencing first-time inventory write-downs. As in previous research, we find that the distributions of our financial variables are characterized by a small number of extreme outliers. We therefore follow the standard procedure of winsorizing observations at the 1st and 99th percentiles of the distribution.

3.1 Economic Impact of Inventory Write-downs

Table 1 presents descriptive statistics for our 290 firms experiencing inventory write-downs. The average inventory write-down in our sample is $13.2 million. This represents 3.7% of a firm's average total assets suggesting that the magnitude of these write-downs is quite significant. The mean firm in our sample experiences a -15.4% return on assets and a -21.5% equally-weighted market adjusted return in the year of an inventory write-down, suggesting that write-downs are associated with extreme negative consequences for shareholders.

To further confirm this result, we conduct a matched sample analysis. We begin with the entire sample of inventory write-down firm years in our sample and match each write-down firm year to one non-inventory write-down firm year. Firms are first matched on calendar year and then 2-digit SIC codes. If a proper two digit match is unavailable then we move to a one digit match. We then require that matched firms be within 20% of total assets and inventory as a percentage of total assets in period \((t-1)\). From the remaining firms that meet these criteria, the firm with the closest change in sales to the write-down firm in period \((t-1)\) is selected as a match\(^7\). Similar matching sample analysis is common in the accounting and finance literatures (e.g., Erickson et al., 2006; Lang et al., 2006). Using the matched firm, we then compare the performance of the firms in period \(t\), the period our write-down sample experiences a significant first time write-down. Table 2 presents the results of our analysis. The matches appear to have similar characteristics in period \(t-1\). Mean sales growth and inventory levels for write-down firms are statistically significantly higher than for the matched sample. Despite the statistical significance the magnitude of the differences is quite small at 5.8 percent of sales and 0.6 percent of average total assets respectively. The median characteristics are nearly identical. The results of primary interest presented in table 2 are the extreme differences between the sample groups in period \(t\) return on assets and stock returns. Inventory write-down firms return on assets is -0.143 lower than matched firms and inventory write-down firms experience stock returns -0.41 lower than matched firms. The results confirm the fact that write-downs have extreme negative consequences for firms.

Table 3 provides descriptive evidence on the industries most likely to experience inventory write-downs. The first column lists the industry, the second column is the percentage breakdown of our inventory write-down sample and the third column is the percentage breakdown of the entire

\(^7\) The matched sample consists of 274 inventory write-down firm observations and 274 matched observations. 16 inventory write-down firm observations were excluded because we were unable to find a satisfactory match.
sample by industry during 2002-2004. The bolded industries are those where the proportion of inventory write-down firms is significantly over represented relative to the proportion of firms in the non write-down sample. Consistent with the notion that inventory write-downs are more likely for firms with extreme sales growth and short product life cycles, we find that write-downs are overrepresented in both heavy industry and computers, semiconductor and computer services.

We would like to highlight the time-series trend in key variables for our inventory write-down sample. Figure 1(a) presents the time-series mean and median change in inventory as a percentage of average total assets. The figure shows that in the periods preceding the inventory write-downs inventory is significantly increasing. This suggests that firms are purchasing significant amounts of inventory prior to the write-down period. Figure 1(b) documents the evolution of firms sales growth prior to and following an inventory write-down. Consistent with the notion that extreme sales growth may be one explanation for inventory write-downs, we find that sales are consistently increasing prior to the write-down period. The mean (median) sales in the periods \((t-4)\) to \((t-2)\) is consistently increasing and growing at a rate of over 25% (10%) each year. In period \((t-1)\) sales growth dramatically slows and then approaches zero in the period of the inventory write-down.

The next two figures document the performance of inventory write-down firms and illustrates the consequences to firms that are forced to write down inventory. Figure 1(c) shows that return on assets (ROA) declines dramatically in the period of the write-down and then bounces back in period \((t+1)\). Figure 1(d) shows that mean market-adjusted returns are positive in the periods \((t-4)\) to \((t-2)\) as sales growth increases, zero in the period prior to the write-down and extremely negative in the year of the write-down. The subsequent bounce back in ROA in the year immediately following the write-down is consistent with the “big bath” phenomenon where firms excessively write-down inventory (Riedl, 2004). This results in subsequent high margins and increased ROA when the inventory is sold. The bounce back in returns is consistent with the accruals anomaly documented first by Sloan (1996).

4 Hypothesis Development

In this section, we set up the hypotheses to relate sales dynamics\(^8\), non-recurring inventory holding costs (write-downs), and inventory ordering policy. The first two hypotheses, presented in Section 4.1, link stochastic inventory write-downs to firms’ sales growth. The subsequent three hypotheses, presented in Section 4.2, connect stochastic inventory write-downs to firms’ ordering behavior. Combining the hypotheses in Section 4.1 and Section 4.2 sheds some light on how firms manage the trade-off between stochastic holding and shortage costs when these are induced by both exogenous (sales growth) and endogenous (inventory policy) factors. We motivate the hypotheses primarily based on results in the theoretical inventory literature.

\(^8\)To test our hypotheses, we use firms’ sales data as a proxy for otherwise unobservable demand data.
4.1 Sales Growth and Inventory Write-downs

First, we test the following hypothesis:

**Hypothesis 1.** The probability of a future inventory write-down is increasing in sales growth.

To our knowledge, there is little or no empirical research that connects sales growth and non-recurring inventory costs. The validity of the above hypothesis may not be obvious because intuition suggests that high sales growth would purge a company of any potential excess inventory.

Under GAAP, companies should recognize an inventory write-down when the value of inventory declines below its original cost. Taking this principle into consideration, we would expect firms that carry higher levels of more rapidly depreciating inventory to be more prone to inventory write-downs than their opposites.

The theoretical result that links high sales growth to high output is found in Veinott (1965b, Theorem 5) who considers a very general dynamic inventory model with non-stationary demand. Veinott (1965b) finds that firms ought to respond to a stochastically increasing demand by upwards adjusting their base-stock inventory level.

The link between increased output and product life cycle is established in Klepper (1996) who asserts that the larger the output of a firm the greater its total spending on R&D (Klepper, 1996, Proposition 7). Since increased R&D spending is widely interpreted to imply greater product innovation and shorter product life cycle, we hypothesize that it also implies a faster pace at which the existing products held in inventory become obsolete.

That is, based on results in Veinott (1965b) and Klepper (1996), we conjecture that as sales growth increases, companies carry larger quantities of inventory that lose value more rapidly, increasing the probability of an inventory write-down. This reasoning also agrees with the anecdotal evidence from the high-tech industry (Teach, 2001).

Should an inventory write-down occur, one of the reasons could be that an inventory build up is followed by a slowdown in sales growth. Since fast growing firms are more prone to inventory write-downs, we would like to test whether extreme sales growth is more prone to a slowdown than moderate sales growth. Extreme growth is defined as the top quintile while moderate growth is associated with the middle quintiles of sales growth rate.

**Hypothesis 2.** Extreme sales growth is less persistent than moderate sales growth.

There is a large empirical literature in accounting and finance that seeks to identify predictable variation in earnings and profitability. One of the findings this literature reports is that high rates of growth in returns on assets (ROA) and returns on equity (ROE) are not sustainable and that, eventually, these rates decay toward some economy-wide level. Stigler (1963) explains this phenomenon using a standard economic argument by noting that competition causes above average growth in returns to erode: “...entrepreneurs seek to leave relatively unprofitable industries and enter relatively profitable ones ...”

In particular, Fama and French (2000) perform a time series study using NYSE, AMEX, and NASDAQ firms on COMPUSTAT with total assets greater than $10 million and document that
changes in ROA mean revert; i.e., they are beset by short-term disturbances but tend toward a long-run mean value. Moreover, the rate of mean reversion is faster when the growth in ROA is further from its mean in either direction. Therefore, the higher the growth rate the less persistent it appears to be.

To develop Hypothesis 2, we now identify a formal link between changes in ROA and changes in sales. Using the standard DuPont analysis, a company’s ROA can be written as a product of profit margin and asset turnover:

\[
\text{ROA} = \text{Profit margin} \times \text{Asset turnover} = \frac{\text{Net income}}{\text{Total sales}} \times \frac{\text{Total sales}}{\text{Avg. total assets}},
\]

from which

\[
\text{ROA} = \frac{\text{Net income}}{\text{Avg. total assets}} = \frac{\text{Total sales} \times \text{Profit margin}}{\text{Avg. total assets}}.
\]

The right side of the above equation reveals that constant profit margin and constant average total assets mean that changes in ROA are driven by changes in total sales. That is:

\[
\text{ROA}_t - \text{ROA}_{t-1} = (\text{Total sales}_t - \text{Total sales}_{t-1}) \times \frac{\text{Profit margin}}{\text{Avg. total assets}}, \quad \text{or}
\]

\[
\text{Total sales}_t - \text{Total sales}_{t-1} = (\text{ROA}_t - \text{ROA}_{t-1}) \times \frac{\text{Avg. total assets}}{\text{Profit margin}}.
\]

(1)

Since the results in Fama and French (2000) imply that high growth in ROA is less persistent than average growth in ROA, then from Equation (1) we hypothesize that the same applies to growth in sales. Nissim and Penman (2001) offer some visual evidence of this but provide no formal test. We formally test the hypothesis that extreme sales growth is less persistent than average sales growth.

4.2 Purchasing Behavior and Inventory Write-downs

We proceed to investigate firms’ purchasing behavior under growing demand and its relationship with non-recurring inventory costs (write-downs).

What would a manager do when facing rapidly growing demand? This question is important for understanding firms’ purchasing behavior because in such an environment often little can be said about an optimal policy and managers must rely on approximations, heuristics, or base-stock models with appropriate “fudge factors,” designed to balance conflicting pressures (for an excellent overview, see Zipkin, 2000, §9).

Inventory theory with non-stationary demand dates back to the early 1960’s. One of the notable results is that when demand stochastically increases over time, the simple base-stock policy is optimal under certain conditions (Karlin, 1960; Veinott, 1965a). In addition, the optimal base-stock levels do not decrease over time. This suggests that it is optimal for firms to purchase more inventory when facing increasing demand. Rapidly increasing demand may also impose a psychological effect on managers’ ordering behavior. It has been widely documented in the literature that over-reaction biases are commonplace in people’s decision making (see, for example, Armstrong and Brodie (1987)
in marketing, Watson and Zheng (2008) in operations management, and Nosic and Weber (2009) in behavioral finance). Anecdotal evidence of firms over-reacting to demand changes abounds in the business press. Just to mention a couple of examples: Cisco Systems was overly optimistic about market demand before the gigantic write-down in 2001 (Burrows, 2003), and John Deere displeased its customers by carrying insufficient inventory because of being pessimistic about the effect of the recent recession (Singh, 2010). The over-reaction effect may also be aggravated by certain practices adopted in many real-world supply chains. For instance, in the networking equipment industry customers are allowed to duplicate orders at multiple suppliers; in the semiconductor industry, customers may place soft orders that might be cancelled at a later stage. Armony and Plambeck (2005) demonstrate that allowing customers to duplicate (and freely cancel) orders will make a firm overestimate the demand rate and hence over-invest in capacity. Based on this discussion, it is natural to conjecture that adjusted for sales, extreme growth firms would carry more inventories than moderately growing firms.

To understand how firms respond to sales growth, we test how much of their sold inventory firms replace. That is, we measure firms’ inventory purchase as a percentage of the sold inventory. (For ease of exposition, we say that a firm with high (low) inventory purchase as a percentage of the sold inventory uses aggressive (conservative) inventory policy.) The main advantage of this approach is that it is impervious to an inventory policy: For example, a particular firm facing i.i.d. demand may use a base-stock or \((Q,r)\) policy; although the policies are different, standard inventory theory predicts that under either policy the firm orders new stock so as to replace any sold stock. First, we test the following hypothesis, which examines the connection between sales growth rate and firms’ purchasing behavior.

**Hypothesis 3.** As a percentage of inventory sold, extreme growth firms replace more inventory than moderate growth firms.

Next, we examine the connection between inventory write-down and firms’ purchasing policy. Note that firms need to write down inventory when the value is lower than the cost. Thus ordering/carrying more inventory will clearly increase the likelihood of a write-down. Since we conjecture that there is a link between growth rate and inventory write-downs, a natural question arises: do extreme growth write-down firms exhibit different purchasing behavior from the other firms? We investigate this question by testing the following two hypotheses:

**Hypothesis 4.** As a percentage of inventory sold, extreme growth firms that experience inventory write-downs replace more inventory prior to a write-down than other extreme growth firms.

**Hypothesis 5.** As a percentage of inventory sold, extreme growth firms that experience inventory write-downs replace more inventory prior to a write-down than moderate growth firms.

Hypothesis 4 compares the ordering behavior of extreme growth firms with and without experiencing inventory write-downs. We expect that these firms exhibit different ordering behavior, which, if true, may help explain why some extreme growth firms were hit by significant write-downs while the rest successfully avoided them. This would offer useful managerial insight that
helps firms reduce the probability of inventory write-downs. Hypothesis 5 goes one step further to compare the ordering behavior of extreme growth firms that experienced write-downs to that of moderately growing firms. We test this hypothesis because the average firms have moderate growth rates and their behavior may serve as a natural benchmark to evaluate that of the extreme growth write-down firms. As it becomes clear in Section 6.2 on page 17, this hypothesis, combined with Hypotheses 3 and 4, provide interesting managerial implications about the firms’ ordering behavior under extreme growth.

5 Methodology

We begin by testing our first hypothesis that the probability of a future inventory write-down is increasing in sales growth. To do this we model the probability that a firm will experience a first inventory write-down (FWD), equal to one for firm-years experiencing a first large inventory write-down and zero otherwise, as a function of previous periods’ sales growth and change in inventory:

\[
PR(WD = 1)_{t+1} = b_0 + b_1 \Delta SALES_t + b_2 \Delta SALES_{t-1} + b_3 \Delta INV_t + b_4 \Delta INV_{t-1} + \epsilon_{t+1}. \tag{2}
\]

We estimate Model (2) using a logistic regression with standard error estimates clustered on firms (Rogers, 1993). If the probability of an inventory write-down is increasing in past sales growth, we expect to find significant positive coefficients for \(b_1\) or \(b_2\). Consistent with previous research by Allen et al. (2010) we also expect that the probability of an inventory write-down is increasing in positive inventory changes. Therefore, we also expect to find positive and significant coefficients for \(b_3\) and \(b_4\).

Next, we present tests for our second hypothesis that extreme sales growth is less persistent than average sales growth. We model sales growth in period \((t + 1)\) as a function of period \(t\) sales growth and interaction terms between sales growth and indicator variables equal to one if a firm experiences extreme sales growth in period \(t\) and zero otherwise. We define extreme sales growth by sorting firms into quintiles each year based on sales growth. If a firm falls in the top quintile in period \(t\), \(ExtremePositive_t\) equals one and zero otherwise. If a firm falls in the bottom quintile, \(ExtremeNegative_t\) equals one and zero otherwise. We estimate the following model using a pooled sample and ordinary least squares (OLS).

\[
\Delta SALES_{t+1} = b_0 + b_1 \Delta SALES_t + b_2 \Delta SALES_{t-1} \times ExtremePositive_t + b_3 \Delta SALES_t \times ExtremeNegative_t + \epsilon_{t+1} \tag{3}
\]

In all of our OLS regressions, we use two-way clustered standard errors, for firms and years, to adjust for both cross-sectional and serial correlation (Petersen, 2009). If Hypothesis 2 is descriptive, we expect to find significant negative coefficients on \(b_2\) and \(b_3\) in Model (3). In addition to testing whether firms falling in the most extreme quintiles of sales growth experience less persistent sales growth relative to other sample firms, we examine how extreme firms compare to firms experiencing
more moderate sales growth. We do this by creating two more interaction terms. The first term, \( \Delta SALES_t \times High_t \), is sales growth for firms falling in the second quintile of sales growth and \( \Delta SALES_t \times Low \) is sales growth for firms falling in the fourth quintile of sales growth.

\[
\Delta SALES_{t+1} = b_0 + b_1 \Delta SALES_t + b_2 \Delta SALES_t \times ExtremePositive_t \\
+ b_3 \Delta SALES_t \times ExtremeNegative_t + b_4 \Delta SALES_t \times High_t \\
+ b_5 \Delta SALES_t \times Low_t + \epsilon_{t+1} \tag{4}
\]

If sales growth for moderate growth firms is less persistent than sales growth for firms falling in the middle quintile of sales growth, we would expect to find significant negative coefficients for \( b_4 \) and \( b_5 \) in Model (4). We would also expect that if extreme sales growth both positive and negative (\( ExtremePositive \) and \( ExtremeNegative \)) is less persistent than more moderate sales growth (\( High \) and \( Low \)) to find that \( b_2 < b_4 \) and \( b_3 < b_5 \).

We now lay out tests of our Hypothesis 3 that, extreme growth firms replace more of their sold inventory than their moderately growing counterparts. We expect that firms make purchasing decisions at the beginning of and during a period based on expectations of sales in the upcoming period. Therefore, we use the approach of modeling levels of purchases scaled by cost of goods sold (\( Purchases_t / COGS_t \)) as a function of contemporaneous changes in sales. Scaling purchases by cost of goods sold has a straightforward and natural interpretation. Firms whose ratio is equal to one (assuming constant costs) are purchasing just enough inventory to replace inventory sold. Whereas, firms with a ratio higher than one are increasing inventory and firms with a ratio lower than one are depleting inventory levels. If managers believe that demand shifts are not completely transitory then we expect to find that as \( \Delta SALES_t \) increases (decreases) \( Purchases_t / COGS_t \) increases (decreases). We examine changes in the ratio of purchases to cost of goods sold in period \( t \) as a function of contemporaneous sales growth and sales growth interacted with indicator variables for extreme positive and negative growth.

\[
Purchases_t / COGS_t = b_0 + b_1 \Delta SALES_t + b_2 \Delta SALES_t \times ExtremePositive_k \\
+ b_3 \Delta SALES_t \times ExtremeNegative_k + \epsilon_t \tag{5}
\]

The \( ExtremePositive \) and \( ExtremeNegative \) indicator variables in Model (5) allow us to test how the purchasing and inventory holding policies of extreme growth firms differ from moderate growth firms. We condition extreme sales growth on two different time periods by setting \( k \) equal to \( (t - 1) \) and \( t \). The appropriate conditioning period for extreme growth, \( (t - 1) \) or \( t \), will depend on the available information managers can use for making purchasing and investing decisions. If managers face long lead times or high fixed costs, it is likely that managers will be forced to make inventory decisions earlier, which would suggest that purchases and inventory will be a function of the extremity of sales growth in \( (t - 1) \). On the other hand, if firms face very short lead times and low fixed costs, then managers will likely be able to adjust their purchase decisions during the period.
based on the current extremity of sales growth. Because lead times and fixed costs associated with inventory are largely unobservable, we present results conditioning on both periods. We expect that if extreme growth firms’ inventory purchasing and holding decisions are similar to moderate growth firms we will find that $b_2 = 0$ and $b_3 = 0$. On the other hand, if we find that $b_2 < 0$ ($b_2 > 0$) this would suggest that, compared to moderately growing firms, extreme positive growth firms tend to shrink (expand) their inventories.

Using only the time period subsample for which we have inventory write-down data (2002-2004), we next test both Hypotheses 4 and 5. Using the identical framework as our tests of Hypothesis 3, we are able to examine the purchasing and inventory holding behavior of firms that ex-post experience inventory write-downs by interacting our extreme growth interaction terms with an additional indicator variable for firms that ex-post experience inventory write-downs.

\[
\frac{\text{Purchases}_t}{\text{COGS}_t} = b_0 + b_1 \Delta \text{SALES}_t + b_2 \Delta \text{SALES}_t \times \text{ExtremePositive}_k \\
+ b_3 \Delta \text{SALES}_t \times \text{ExtremeNegative}_k + b_4 \Delta \text{SALES}_t \times \text{ExtremePositive}_k \times \text{FWD}_{t+1} \\
+ b_5 \Delta \text{SALES}_t \times \text{ExtremeNegative}_k \times \text{FWD}_{t+1} + \epsilon_t \tag{6}
\]

Similar to our previous tests, we condition on extreme sales growth in both periods $t$ and $(t - 1)$. If extreme growth firms that experience subsequent write-downs purchase and hold more inventory than other extreme growth firms, then we expect to find that $b_4$ in Model (6) is positive and significant. We can test our final hypothesis that extreme growth firms that experience inventory write-downs purchase and hold more inventory prior to a write-down than moderate growth firms using the same model. By examining the sum of the coefficients $b_4$ and $b_2$, we can compare extreme growth firms that subsequently experience inventory write-downs to moderate growth firms. If extreme growth write-down firms purchase significantly more inventory than average sales growth firms, we expect to find that $b_4 + b_2 > 0$. On the other hand, if we find that $b_4 + b_2 = 0$ this would suggest that extreme growth write-down firms behave similarly to moderate growth firms.

6 Results

6.1 Sales Growth and Inventory Write-down Results

Before providing formal tests for our first hypothesis, we provide additional descriptive evidence on the relation between sales growth and inventory write-downs. Referring back to Figure 1(b), it appears that there is an increasing trend in sales growth especially in the periods $(t - 3)$ and $(t - 2)$ relative to the inventory write-down period, $t$. In Figure 2, we provide evidence on the distributional properties of the data points in Figure 1(b). Sales growth is ranked each year into quintiles using the entire sample of inventory write-down and non inventory write-down firms. Figure 2 presents the percentage of the inventory write-down firms falling into each quintile of sales growth in the period of the inventory write-down, $t$, and the three periods prior to inventory write-downs, $(t - 1)$, $(t - 2)$, and $(t - 3)$. The mean size of the inventory write-down scaled by average total assets.
for firms falling in each quintile is presented at the top of each bar. If there is no relationship between sales growth and inventory write-downs, we would expect to find that approximately 20% of write-down firms fall in each quintile. Not surprisingly, in the period of the inventory write-down the lowest sales growth quintile is extremely overrepresented by write-down firms (41.3%). In the period immediately prior to a write-down it appears that the firms are distributed fairly evenly across quintiles. While in periods \((t - 2)\) and \((t - 3)\), the strongest representation of write-down firms appears in the fastest sales growth quintile (31.1% and 27.3% respectively). These also appear to be the most extreme write-downs as the mean write-down is -4.2% and -4.1% of average total assets in periods \((t - 2)\) and \((t - 3)\) respectively. This descriptive evidence is consistent with a positive relation between sales growth and inventory write-downs especially in periods \((t - 2)\) and \((t - 3)\). We now provide formal statistical tests for our first hypothesis.

Table 4 presents regression results for our first hypothesis. Equation (A) presents results for sales growth alone. Equation (B) presents results for just changes in inventory, and Equation (C) presents results for both sales growth and changes in inventory. The results are consistent with our hypothesis. It appears that sales growth in the period immediately prior to an inventory write-down has no significant explanatory power, consistent with the evidence provided in Figure 2(b). But, sales growth two periods prior to an inventory write-down does have significant explanatory power in the predicted direction. In Figure 1, sales growth is extremely positive for inventory write-down firms in periods \((t - 4)\) to \((t - 2)\). In period \((t - 1)\) sales growth slows significantly. A comparison of the inventory write-down firms’ sales growth in period \((t - 1)\) and average sales growth in the non-inventory write-down sample suggests there is no difference. This result suggests two possible scenarios: (1) Managers are slow to recognize inventory write-downs in accounting earnings and thus delay the write-downs until they are forced to write-down inventory by auditors, or (2) managers do not believe that sales growth will continue to decline and expect that as a result inventory will maintain its value. Under either circumstance, it appears that positive sales growth, in particular in period \((t - 2)\), is positively associated with inventory write-downs. In Equation (B), we document that inventory write-downs are also increasing in positive changes in inventory. This should not be surprising. If firms were able to decrease inventory prior to a write-down by selling the inventory for its book value, firms would not be forced to incur a write-down. The buildup in inventory along with decreasing sales growth is a signal that firms have excess inventory on their balance sheets that they are unable to sell.

Now that we have established Hypothesis 1, we next examine the persistence of sales growth. We begin by providing some descriptive evidence in the form of a figure, and then we statistically test whether extreme growth is less persistent than moderate growth. We first sort firms into sales growth quintiles based on sales growth in period \(t\) and then plot mean sales growth for period \(t\) and the subsequent four years. Figure 3, similar to Nissim and Penman (2001), clearly shows that mean sales growth reverts at a quick rate. The extreme sales growth both positive and negative appears to dissipate within one to two periods. The mean reversion in the negative sales growth term might be the result of a survivorship bias in the data as firms that experience negative sales
growth must either turn the trend around or go out of business. For this reason, we spend little

time examining the results of extreme negative sales growth firms but focus our attention on firms

experiencing extreme positive sales growth. Although Figure 3 provides strong visual evidence that

sales growth for extreme firms is unlikely to be persistent, we provide statistical evidence for this

in Table 5.

Table 5, Equation (A) shows that on average sales growth exhibits some persistence although it

is significantly less than one. Equation (B) includes interaction terms for extreme negative and posi-
tive growth. The negative and significant coefficients for both \( \Delta \text{SALES}_t \times \text{ExtremePositive}_t \) and \( \Delta \text{SALES}_t \times \text{ExtremeNegative}_t \) suggest that extreme sales growth is much less persistent than sales growth for non-extreme firms. In fact, extreme negative sales growth completely reverses (0.361 – 0.412) and sales growth for extreme positive firms is 39% less persistent than for moderate growth firms. We further explore the persistence of sales growth in Equation (C) by introducing in-
teraction terms for moderate sales growth, those falling in quintiles 2 and 4. The persistence of firms

falling in the middle quintile of sales growth is represented by the coefficient on \( \Delta \text{SALES}_t \). The ev-

idence in Equation (C) for extreme growth firms is consistent with Equation (B) and confirms that

indeed extreme sales growth is less persistent than moderate sales growth. The insignificant coeffi-
cients on \( \Delta \text{SALES}_t \times \text{HIGH}_t \) and \( \Delta \text{SALES}_t \times \text{LOW}_t \) suggest that moderate sales growth is just as

persistent as mean sales growth. To statistically confirm that \( \Delta \text{SALES}_t \times \text{ExtremePositive}_t \) and \( \Delta \text{SALES}_t \times \text{ExtremeNegative}_t \) differ from \( \Delta \text{SALES}_t \times \text{HIGH}_t \) and \( \Delta \text{SALES}_t \times \text{LOW}_t \) respectively, we conduct F-tests comparing the coefficients. Statistical equivalence is soundly rejected at the less than 1% level. All of our results confirm our second hypothesis that extreme sales growth is less persistent than moderate sales growth.

6.2 Purchasing Behavior and Inventory Write-down Results

Tables 6 and 7 provide results for tests of Hypothesis 3. Table 6 regresses changes in purchases

scaled by cost of goods sold in period \( t \) on contemporaneous changes in sales and interaction terms

for firms experiencing extreme sales growth in the prior period, \( (t – 1) \). Table 7 is identical to

Table 6 except that extreme growth is conditional on time \( t \) rather than \( (t – 1) \). We condition

on both time periods to show that our results are robust to the timing of inventory decisions. If

one assumes that purchase decisions are made primarily at the beginning of the period then the

more appropriate tests are likely those presented in Table 6. On the other hand, if one assumes

that firms have the ability to significantly adjust purchase decisions during the period, perhaps

the results presented in Table 7 are more descriptive. We present both tables to demonstrate the

results are robust to either assumption. The primary coefficients of interest in our specifications are

\( \Delta \text{Sales}_t \times \text{ExtremePositive}_{t-1} \) in Table 6 and \( \Delta \text{Sales}_t \times \text{ExtremePositive}_t \) in Table 7. As outlined

in the methodology section, we expect that if positive extreme growth firms behave consistent with

Hypothesis 3, we will find that these coefficients are positive and significant suggesting that extreme

sales growth leads to more aggressive replacement of inventory relative to sales leading to higher

ending inventory.
Contrary to our conjectures in Hypothesis 3, we find that consistently across all specifications the signs are negative and significant. This suggests that extreme growth firms replace less of their sold inventory than firms that do not experience extreme growth. To illustrate this, Equation (B) of Table 6 shows that firms experiencing no sales growth replace approximately 100% of their inventory sold (Const. = 1.007). This is reassuring because it corroborates a prediction from the standard inventory theory: That is, in a stationary demand environment, firms optimally use a policy (e.g., \((r, Q)\) or base-stock policy, depending on the presence of fixed costs) that merely replaces any sold stock.

Firms experiencing moderate sales growth either positive or negative replace approximately 100% of inventory sold during a period plus 11.8% of sales growth. For example, if a firm were to experience 10% positive (negative) sales growth in period \(t\) the equation suggests that on average this firm would have a ratio of purchases to cost of goods sold of 1.0188 (0.9952). Thus, firms experiencing positive sales growth increase ending inventory levels; while, firms experiencing negative sales growth decrease ending inventory levels. This also corroborates predictions from the theoretical literature: When firms experience moderate sales growth, time-dependent base-stock or \((r, Q)\) policies, under which base-stock level and re-order point respectively move in parallel with lead-time demand, are known to perform well (Zipkin, 2000, §9.2.2) and Equation (B) in Table 6 appears consistent with the use of such policies.

However, the rejection of Hypothesis 3 indicates that firms do not necessarily adopt more aggressive inventory policies when facing faster sales growth. When firms experience large and sudden changes in demand, often, base-stock and \((r, Q)\) structures continue to be optimal; but due to the curse of dimensionality, computing the optimal policy parameters is not easy at all (for an extended discussion, see Zipkin, 2000, §9.7).

Essentially, firms have to resolve the conflict between two pressures when making inventory decisions: the pressure for high inventories includes reduction of backorders and stockouts, institutional reasons that lead rational inventory managers to amplify changes in demand (Gilbert, 2005; Kahn, 1987), and shortage gaming (Lee et al., 1997); pressure for low inventories includes high holding cost and risk of incurring obsolescence cost (Song and Zipkin, 1993, 1996).

Controlling for sales growth, the interaction terms in Equation (B) provide evidence that extreme growth firms appear to replace stock at a lower rate than moderate growth firms. The finding suggests that on average extreme growth firms choose to resolve the conflicting pressures in favor of lower inventories, possibly due to the heightened risk of inventory write-downs, which has been generally disregarded in the theoretical literature.

The last observation also raises the question whether firms with extreme growth that subsequently experience inventory write-downs behave similarly to other extreme growth firms. We examine this question and test our concluding two hypotheses by estimating similar regressions as those presented in Tables 6 and 7, but this time we include interaction effects for firms that ex-post experience inventory write-downs. This allows us to determine whether extreme growth firms that ex-post experience inventory write-downs behave similarly to non-inventory write-down
extreme growth firms. Due to constraints associated with hand collecting inventory write-down data, our sample is limited to the 2002-2004 time period. Tables 8 and 9 present our results. Table 8 corresponds in nature to Table 6 because the extreme sales growth interaction variables are conditional on previous period’s sales growth. While, Table 9 corresponds to Table 7 because extreme sales growth is conditional on current period’s sales growth. To show that our previous results hold in this more limited sample period, we first estimate the models without inventory write-down interaction terms. In Equations (B) for both tables, we find similar results. Extreme positive growth firms appear to replenish inventory relative to current period sales growth at a lower rate than firms that experience moderate sales growth.

Now we turn our focus to the more extensive specification, Equation (C) of Table 8. We are primarily interested in the coefficient on $\Delta \text{SALES}_t \times \text{ExtremePositive}_{t-1} \times \text{FWD}_{t+1}$. If extreme growth firms that ex-post experience inventory write-downs behave as other extreme growth firms, we expect the coefficients to be statistically insignificant. On the other hand, if we find that the coefficients are positive, this suggests that firms that experience extreme growth and inventory write-downs behave more aggressively than other extreme growth firms in that they replace inventory sold at higher rates. Consistent with Hypothesis 4, conditional on extreme positive sales growth in $(t - 1)$, we find that inventory write-down firms purchase more inventory and thus increase ending inventory levels more than non-inventory write-down firms in the period immediately prior to an inventory write-down.

For comparison with the results in previous tests, Table 9 examines the results conditional on extreme sales growth in period $t$. Conditioning on extreme growth in period $t$, is likely to provide weaker results than conditioning on period $(t - 1)$. Referring back to Figure 1(b), the significant decrease in sales growth in the period immediately prior to the write-down suggests that very few inventory write-down firms experience extreme growth in the period immediately prior to an inventory write-down. This was also confirmed by our logistic results in Table 4. The results in Table 9 are signed similarly as those found in Table 8 but the coefficient on $\Delta \text{SALES}_t \times \text{ExtremePositive}_{t} \times \text{FWD}_{t+1}$ is smaller and insignificant. Despite this lack of significance the results in Table 8 along with solid ex-ante reasons for weak results in Table 9 provide support for the hypothesis that extreme growth firms that ex-post experience inventory write-downs replace inventory more aggressively than other extreme growth firms in the period immediately prior to a write-down.

To test our last hypothesis, that extreme growth firms that experience inventory write-downs purchase and hold more inventory prior to a write-down than moderate growth firms, we conduct an $F$-test to determine whether the joint effect of $\Delta \text{SALES}_t \times \text{ExtremePositive}_{t-1} \times \text{FWD}_{t+1}$ and $\Delta \text{SALES}_t \times \text{ExtremePositive}_{t-1}$ differs from zero. The test statistic is extremely insignificant with an $F$-statistics of 0.05 and a $P$-value of 0.819. This result suggests that extreme growth inventory write-down firms’ purchasing behavior is no different than the behavior of average firms. Therefore, we are unable to provide any evidence in support of Hypothesis 5.

The tests of Hypotheses 4 and 5 suggest that extreme growth firms with write-downs tend
to carry more inventory than other extreme growth firms. However, we do not find evidence of exuberant inventory purchases among these firms: In fact, inventory policy of an average extreme growth firm with write-downs is statistically indistinguishable from that of a firm experiencing only moderate or no sales growth. Future research may explore whether this finding implies that inventory policies used by moderately growing firms are inappropriate for extreme growth firms. To our knowledge, the theoretical literature has not considered this issue. We can, however, measure the economic impact of write-downs on extreme growth firms. The results are summarized in Section 3.

7 Summary and Future Research

Inventory write-downs that cause substantial losses to firms have been frequently reported in business media during the past few decades. As a result of mismatch between supply and demand, inventory write-downs may have a severe impact on firms’ operating performance. For the 290 firms in our inventory write-down sample, there is a -15.4% return on assets on average in the year of the inventory write-down (the corresponding market-adjusted return is -21.5%). The economic impact of write-downs is so significant that firms need to take such potential adverse events into account when making inventory decisions. Although both practitioners and academics surely understand its importance, there has been little research devoted to the study of (how to manage) inventory write-downs in today’s competitive, fast changing market environment. In this paper, we empirically analyze inventory write-downs and try to derive useful insights to firms in managing inventory and sales growth. Below we summarize the managerial implications from our study and point out some promising directions for future research.

It has been shown that the probability of an inventory write-down increases in sales growth (Hypothesis 1). Intuitively, one may conjecture that extreme growth firms should be concerned about securing supplies to avoid shortages. But our result suggests that these firms should also be alert to the potential risk of inventory write-downs. This is mainly because high sales growth is not sustainable. In particular, we have found empirical evidence that high sales growth is less persistent than moderate sales growth (Hypothesis 2). Thus, managers should carefully factor the lower persistence of high growth in their inventory decisions. Overlooking or under-estimating such an effect will raise the level of excess inventory when the demand rate deteriorates and therefore increase the risk of an inventory write-down. Additionally, investing in information systems to improve demand visibility and forecasting capability seem to be rather important when dealing with unpredictable growth. The quicker the firm can identify a turnaround in the growth pattern, the more likely it can react promptly to avoid potential excess inventory buildup.

The link between sales growth and inventory write-downs inspires us to investigate firms’ inventory purchasing policies under high sales growth. Our analysis shows that no-growth firms generally follow a one-for-one replenishment policy (i.e., they simply replace what they sell). This seems to be consistent with theoretical predictions that simple base-stock type policies perform well under
stationary demand environments. With moderate growth, firms on average purchase an additional 11.8% of sales growth. However, Hypothesis 3, which states that high growth firms use a more aggressive purchasing policy, has been rejected by the empirical test. In fact, it has been found that the high growth firms replace less inventory sold than moderate growth firms. Overall we can see that the aggressiveness of firms' inventory policy is not necessarily monotone in sales growth rate: Although moderate growth firms tend to replace more stock sold than no growth firms, high growth firms behave more conservatively than the moderate growth firms. As discussed in Section 4.2, various arguments from the literature would lead to a conjecture that firms purchase inventory more aggressively when facing fast growth rate. In contrast, we find that, on average, this is not the case.

Why do high growth firms exhibit such conservative ordering behavior? We postulate two non-mutually exclusive stories to answer this question. The first potential story is that managers are aware of the lower persistence of high growth, and therefore take precautionary actions accordingly. The second potential story is that high growth firms appear to behave cautiously with respect to purchases and inventory not because they are cautious but because they cannot meet demand. The high growth in demand results in inventory shortages due to limited production capacity or long supply lead times. These inventory shortages show up in the data as a conservative purchasing policy and lower inventory levels. A prominent example that fits into this story is Cisco Systems: As reported by the media, Cisco experienced huge amount of backlogged demand and tried every means (e.g., ramp up capacity and place orders for parts and components) to catch up with the fast sales growth before the 2001 inventory write-down (Burrows, 2003).

By using cross-firm comparison, our analysis also demonstrates that there is an association between inventory write-downs and firms’ purchasing and inventory holding policies. The acceptance of Hypothesis 4 is not surprising. It confirms the intuition that under high growth, the write-down firms adopt more aggressive ordering and inventory policies than the no-write-down firms. This finding, though intuitive, offers useful guidelines to firms seeking appropriate inventory strategies under high growth. The overly aggressive policies of the write-down firms could be due to following reasons: First, the write-down firms under-estimate the low persistence of high sales growth; second, the pressure of inventory shortages make the write-down firms over-invest in capacity and raw materials, causing them to overshoot demand; third, the write-down firms are unable to adjust their short-term inventory because they use inflexible ordering systems or have locked in capacity through long-term supply contracts. Therefore, in order to reduce the inventory write-down risk, firms under high growth should be cognizant of the low persistence of sales growth, exert caution when investing in capacity, and ensure that the ordering systems are as nimble and accurate as possible.

The rejection of Hypothesis 5 means that the high growth write-down firms exhibit similar behavior to the moderate growth firms, which is not intuitive. The implication of this result is two-fold. On one hand, it suggests that high growth write-down firms are unable to properly adjust their inventory strategy when entering the high sales growth region. This could be either because
they do not know how to do it, or simply because they fail to realize that such an adjustment is necessary and important. Second, the ordering policy that works fine under moderate growth may actually heighten the inventory write-down risk under high growth. Therefore, it is critical for firms to carefully adjust their purchasing policies when switching between different phases of growth (future research may address how to identify each phase). This may require a very flexible and agile supply system. For instance, firms may try to procure from suppliers that can provide responsive deliveries. Instead of locking in long-term supply/capacity to take advantage of low cost, firms may try to use shorter-term contracts with flexible supply terms.

In summary, the above results indicate that growing demand and obsolescence risks present remarkable challenges to operations managers. To meet this challenge, (high growth) firms need to pay attention to both ends of their supply chains. For the customer end, firms should invest in information technology to improve demand transparency throughout the supply chain. This will help firms better forecast future demand changes. For the supplier end, firms should exert effort to shorten supply lead times and negotiate flexible supply contracts. In fact, many high-tech firms have learned the lesson from Cisco’s great inventory correction and are trying to make their supply chains shorter, more transparent and as flexible as possible (Teach, 2001).

Inventory management appears particularly challenging for firms experiencing high sales growth. A more cautious purchasing policy can reduce the potential risk of inventory write-downs. But an overly cautious policy may lead to lost sales and unsatisfactory service level. Future research may address the question of an appropriate ordering policy for high growth firms. This appears to be an under-explored research area in the literature. Song and Zipkin (1996) were among the first to look into inventory control with the prospect of obsolescence (their paper was published in a special issue on new directions in operations management). However, they assume a constant unit value of inventory and do not consider the impact of inventory write-downs. Graves (1999) studies an inventory model where demand is non-stationary and governed by an autoregressive process. Wagner (2002, p.224) points out the need for useful heuristics: “...these should take notice of rules of thumb that may seem too simple ... but may function well in a non-stationary environment that contains [multiple] uncertainties.”
References


# Appendix

## Table 1: Summary statistics for write-down firm years

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory Write-down$_t$ (millions)</td>
<td>13.208</td>
<td>45.684</td>
<td>0.07</td>
<td>559</td>
<td>290</td>
</tr>
<tr>
<td>WD$_t$</td>
<td>-0.037</td>
<td>0.036</td>
<td>-0.195</td>
<td>-0.01</td>
<td>290</td>
</tr>
<tr>
<td>Total Assets$_t$ (millions)</td>
<td>496.027</td>
<td>1347.836</td>
<td>1.985</td>
<td>14964</td>
<td>290</td>
</tr>
<tr>
<td>Sales$_t$ (millions)</td>
<td>412.962</td>
<td>991.787</td>
<td>0.996</td>
<td>10542</td>
<td>290</td>
</tr>
<tr>
<td>ROA$_t$</td>
<td>-0.154</td>
<td>0.253</td>
<td>-0.877</td>
<td>0.268</td>
<td>290</td>
</tr>
<tr>
<td>PURCHASES$_t$/COGS$_t$</td>
<td>0.948</td>
<td>0.162</td>
<td>0.651</td>
<td>1.532</td>
<td>290</td>
</tr>
<tr>
<td>∆SALES$_t$</td>
<td>0.027</td>
<td>0.436</td>
<td>-0.545</td>
<td>2.764</td>
<td>290</td>
</tr>
<tr>
<td>INV$_t$</td>
<td>0.203</td>
<td>0.138</td>
<td>0.01</td>
<td>0.648</td>
<td>290</td>
</tr>
<tr>
<td>∆INV$_t$</td>
<td>-0.024</td>
<td>0.081</td>
<td>-0.197</td>
<td>0.281</td>
<td>290</td>
</tr>
<tr>
<td>RET$_t$</td>
<td>-0.023</td>
<td>0.820</td>
<td>-0.982</td>
<td>4.587</td>
<td>285</td>
</tr>
<tr>
<td>EWRET$_t$</td>
<td>-0.215</td>
<td>0.661</td>
<td>-1.636</td>
<td>3.699</td>
<td>285</td>
</tr>
</tbody>
</table>

Sample consists of 290 firms experiencing a first time inventory write-down of more than 1% of average total assets between calendar years 2002 and 2004. WD is measured as the hand collected inventory write-down amount scaled by average total assets. ROA is measured as income before extraordinary items scaled by average total assets. PURCHASES$_t$/COGS$_t$ is measured as purchases (ending inventory plus cost of goods sold minus beginning inventory) divided by cost of goods sold. ∆SALES is measured as the year-over-year percentage change in sales. INV is measured as inventory scaled by total assets. ∆INV is measured as change in inventory scaled by average total assets. RET is the annual buy-hold returns measured beginning four months after the beginning of the fiscal year until three months after the end of the fiscal year. EWRET is the buy-hold annual return less the compounded monthly annual equally-weighted return. All variables with the exception of returns are winsorized at the 1st and 99th percentiles.
### Table 2: Matched Sample Tests

<table>
<thead>
<tr>
<th></th>
<th>WD Sample</th>
<th>Matched Sample</th>
<th>Difference in Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>Total Assets&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>427.8</td>
<td>123.0</td>
<td>425.6</td>
</tr>
<tr>
<td>INV&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.204</td>
<td>0.185</td>
<td>0.199</td>
</tr>
<tr>
<td>∆SALES&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.173</td>
<td>0.031</td>
<td>0.115</td>
</tr>
<tr>
<td>ROA&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-0.173</td>
<td>-0.095</td>
<td>-0.030</td>
</tr>
<tr>
<td>RET&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-0.033</td>
<td>-0.235</td>
<td>0.377</td>
</tr>
</tbody>
</table>

The WD sample consists of 274 inventory write-down firms and the matched sample consists of 274 matched firms. Firms are first matched on calendar year then 2-digit SIC codes and then 1-digit SIC codes if a proper 2 digit match is unavailable. Matched firms must be within 20% of total assets and inventory as a percentage of total assets in period (<sub>t−1</sub>). From the remaining firms that meet the previous criteria, the firm with the closest change in sales to the write-down firm in period (<sub>t−1</sub>) is selected as a match. ROA is measured as income before extraordinary items scaled by average total assets. ∆SALES is measured as the year-over-year percentage change in sales. RET is the annual buy-hold returns measured beginning four months after the beginning of the fiscal year until three months after the end of the fiscal year. All variables with the exception of returns are winsorized at the 1st and 99th percentiles. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level.
<table>
<thead>
<tr>
<th>Industry</th>
<th>Write-down Sample</th>
<th>Entire Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Forestry and Fishing</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Mining and Construction</td>
<td>0.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Food and Tobacco</td>
<td>2.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Textile and Apparel</td>
<td>0.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Lumber, Furniture and Paper</td>
<td>1.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Chemicals</td>
<td>1.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Refining and Extractive</td>
<td>0.3</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Heavy Industry</strong></td>
<td><strong>47.2</strong></td>
<td><strong>34.6</strong></td>
</tr>
<tr>
<td><strong>Computers, Semiconductor and Computer Services</strong></td>
<td><strong>25.2</strong></td>
<td><strong>12.8</strong></td>
</tr>
<tr>
<td>Transport, Pipelines and Telecom</td>
<td>0.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Wholesale, Retail and Restaurants</td>
<td>10.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Services and Conglomerates</td>
<td>5.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Drugs and Medical Equipment</td>
<td>5.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Industries in bold are significantly overrepresented in the write-down sample relative to the total sample at the .01 level. Industries are classified based on SIC codes as follows: Agriculture, Forestry and Fishing (0-999), Mining and Construction (1000-1299,1400-1999), Food and Tobacco (2000-2141), Textile and Apparel (2200-2399), Lumber, Furniture and Paper (2400-2796), Chemicals (2800-2824,2840-2899), Refining and Extractive (2900-2999, 1300-1399), Heavy Industry (3000-3569, 3580-3669, 3680-3999), Computers, Semiconductor and Computer Services (7370-7379, 3570-3579, 3670-3679), Transport, Pipelines and Telecom (4000-4899), Wholesale, Retail and Restaurants (5000-5999), Services and Conglomerates (7000-7369), Drugs and Medical Equipment (2830-2836, 3829-3851).
(a) Change in inventory relative to year of inventory write-down.

(b) Percentage change in sales relative to year of inventory write-down.

(c) Change in ROA relative to year of inventory write-down.

(d) Market-adjusted returns relative to year of inventory write-down.

Figure 1: Inventory write-down sample from 2002-2004 (N=290)
The entire sample of firms is sorted each year on sales growth and ranked into quintiles. Quintiles are sorted from the highest sales growth on the left to lowest sales growth on the right. The figure above the columns represents the mean inventory write-down scaled by average total assets for firms in that sales growth quintile.

Figure 2: Sales growth quintiles for write-down firms in periods $t$, $(t - 1)$, $(t - 2)$ and $(t - 3)$ relative to write-down
Table 4: Logistic regressions of inventory write-down \((t + 1)\) regressed on changes in inventory and sales (2002-2004)

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta SALES_t)</td>
<td>-.070 \hspace{1cm} (.158)</td>
<td>-.205 \hspace{1cm} (.205)</td>
<td></td>
</tr>
<tr>
<td>(\Delta SALES_{t-1})</td>
<td>.283*** \hspace{1cm} (.080)</td>
<td>.190* \hspace{1cm} (.097)</td>
<td></td>
</tr>
<tr>
<td>(\Delta INV_t)</td>
<td>2.182* \hspace{1cm} (1.154)</td>
<td>2.708** \hspace{1cm} (1.240)</td>
<td></td>
</tr>
<tr>
<td>(\Delta INV_{t-1})</td>
<td>4.243*** \hspace{1cm} (1.035)</td>
<td>3.557*** \hspace{1cm} (1.146)</td>
<td></td>
</tr>
<tr>
<td>Const.</td>
<td>-3.392*** \hspace{1cm} (.062)</td>
<td>-3.414*** \hspace{1cm} (.064)</td>
<td>-3.431*** \hspace{1cm} (.066)</td>
</tr>
<tr>
<td>Obs.</td>
<td>8192</td>
<td>8223</td>
<td>8184</td>
</tr>
</tbody>
</table>

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 2002 and 2004 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods \((t - 1), t, \) and \((t + 1), \) and purchases to cost of goods sold in period \(t.\) The dependent variable, FWD, equals 1 for the 290 firms experiencing a first-time inventory write-down of more than 1% of average total assets and 0 otherwise. \(\Delta SALES\) is measured as the year-over-year percentage change in sales. \(\Delta INV\) is measured as change in inventory scaled by average total assets. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level
The entire sample of firms is sorted each year on sales growth and ranked into quintiles. Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 1980 and 2008 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods \((t - 1), t, \) and \((t + 1)\), and purchases to cost of goods sold in period \(t\).
Table 5: Sales growth persistence

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ΔSALES_t</strong></td>
<td>.197*** (.010)</td>
<td>.361*** (.031)</td>
<td>.334*** (.046)</td>
</tr>
<tr>
<td><strong>ΔSALES_t \times \text{ExtremePositive}_t</strong></td>
<td>-.139*** (.023)</td>
<td>-.111*** (.041)</td>
<td></td>
</tr>
<tr>
<td><strong>ΔSALES_t \times \text{ExtremeNegative}_t</strong></td>
<td>-.412*** (.045)</td>
<td>-.383*** (.057)</td>
<td></td>
</tr>
<tr>
<td><strong>ΔSALES_t \times \text{HIGH}_t</strong></td>
<td></td>
<td>.036 (.033)</td>
<td></td>
</tr>
<tr>
<td><strong>ΔSALES_t \times \text{LOW}_t</strong></td>
<td></td>
<td>-.078 (.076)</td>
<td></td>
</tr>
<tr>
<td>Const.</td>
<td>.080*** (.008)</td>
<td>.057*** (.008)</td>
<td>.057*** (.008)</td>
</tr>
<tr>
<td>Obs.</td>
<td>87335</td>
<td>87335</td>
<td>87335</td>
</tr>
<tr>
<td>R^2</td>
<td>.062</td>
<td>.067</td>
<td>.067</td>
</tr>
</tbody>
</table>

Eq (C) \text{ΔSALES}_t \times \text{ExtremePositive}_t = \text{ΔSALES}_t \times \text{HIGH}_t, F-statistic=48.26, P-value=0.00
Eq (C) \text{ΔSALES}_t \times \text{ExtremeNegative}_t = \text{ΔSALES}_t \times \text{LOW}_t, F-statistic=10.68, P-value=0.00

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 1980 and 2008 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods (t − 1), t, and (t + 1), and purchases to cost of goods sold in period t. \text{ΔSALES}_t is measured as the year-over-year percentage change in sales. \text{ExtremePositive}_t and \text{ExtremeNegative}_t are indicator variables equal to 1 if a firm ranks in the top or bottom quintiles respectively of sales growth in year t and 0 otherwise. \text{High}_t and \text{Low}_t are indicator variables equal to 1 if a firm ranks in the 4th or 2nd quintile respectively of sales growth in year t and 0 otherwise. Standard errors are estimated using two-way clustering on firms and years. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level
Table 6: Purchases scaled by cost of goods sold in $t$ regressed on change in $t$ sales

\[
\frac{PURCHASES_t}{COGS_t}
\]

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta SALES_t$</td>
<td>0.093***</td>
<td>0.118***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremePositive_{t-1}$</td>
<td></td>
<td>-0.032***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremeNegative_{t-1}$</td>
<td></td>
<td>-0.036***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>Const.</td>
<td>1.008***</td>
<td>1.007***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Obs.</td>
<td>87335</td>
<td>87335</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.132</td>
<td>0.136</td>
</tr>
</tbody>
</table>

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 1980 and 2008 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods ($t - 1$), $t$, and ($t + 1$), and purchases to cost of goods sold in period $t$. The dependent variable, \( \frac{PURCHASES_t}{COGS_t} \), is measured as purchases (ending inventory plus cost of goods sold minus beginning inventory) divided by cost of goods sold. \( \Delta SALES_t \) is measured as the year-over-year percentage change in sales. \( ExtremePositive_{t} \) and \( ExtremeNegative_{t} \) are indicator variables equal to 1 if a firm ranks in the top or bottom quintiles respectively of sales growth in year $t$ and 0 otherwise. Standard errors are estimated using two-way clustering on firms and years. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level.
Table 7: Purchases scaled by cost of goods sold in $t$ regressed on change in $t$ sales

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta Sales_t$</td>
<td>(0.093^{***})</td>
<td>(0.132^{***})</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>$\Delta Sales_t \times ExtremePositive_t$</td>
<td>(-0.053^{***})</td>
<td>(-0.053^{***})</td>
</tr>
<tr>
<td></td>
<td>(-0.008)</td>
<td>(-0.008)</td>
</tr>
<tr>
<td>$\Delta Sales_t \times ExtremeNegative_t$</td>
<td>(0.089^{***})</td>
<td>(0.089^{***})</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Const.</td>
<td>(1.008^{***})</td>
<td>(1.012^{***})</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Obs.</td>
<td>87335</td>
<td>87335</td>
</tr>
<tr>
<td>$R^2$</td>
<td>(0.132)</td>
<td>(0.15)</td>
</tr>
</tbody>
</table>

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 1980 and 2008 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods \((t-1), t, \text{ and } (t+1)\), and purchases to cost of goods sold in period \(t\). The dependent variable, $PURCHASES_t/COGS_t$, is measured as purchases (ending inventory plus cost of goods sold minus beginning inventory) divided by cost of goods sold. $\Delta Sales_t$ is measured as the year-over-year percentage change in sales. $ExtremePositive_t$ and $ExtremeNegative_t$ are indicator variables equal to 1 if a firm ranks in the top or bottom quintiles respectively of sales growth in year \(t\) and 0 otherwise. Standard errors are estimated using two-way clustering on firms and years. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level
Table 8: Purchases scaled by cost of goods sold in $t$ regressed on change in $t$ sales, extreme growth indicators for $(t - 1)$ and write-down indicators for $(t + 1)$

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta SALES_t$</td>
<td>.074***</td>
<td>.110***</td>
<td>.110***</td>
</tr>
<tr>
<td></td>
<td>(.005)</td>
<td>(.006)</td>
<td>(.006)</td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremePositive_{t-1}$</td>
<td></td>
<td>-0.037***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.010)</td>
<td></td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremeNegative_{t-1}$</td>
<td></td>
<td>-0.050***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.017)</td>
<td></td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremePositive_{t-1} \times WD_{t+1}$</td>
<td>.043***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.016)</td>
<td></td>
</tr>
<tr>
<td>$\Delta SALES_t \times ExtremeNegative_{t-1} \times WD_{t+1}$</td>
<td>-.031*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.018)</td>
<td></td>
</tr>
<tr>
<td>Const.</td>
<td>.997***</td>
<td>.996***</td>
<td>.996***</td>
</tr>
<tr>
<td></td>
<td>(.004)</td>
<td>(.003)</td>
<td>(.003)</td>
</tr>
<tr>
<td>Obs.</td>
<td>8386</td>
<td>8174</td>
<td>8174</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.129</td>
<td>.121</td>
<td>.122</td>
</tr>
</tbody>
</table>

Eq (C) $\Delta SALES_t \times ExtremePositive_t + \Delta SALES_t \times ExtremePositive_{t-1} \times WD_{t+1} = 0$ F-statistic=0.05, P-value=0.819

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 2002 and 2004 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods $(t - 1)$, $t$, and $(t + 1)$, and purchases to cost of goods sold in period $t$. The dependent variable, $PURCHASES_t/COGS_t$, is measured as purchases (ending inventory plus cost of goods sold minus beginning inventory) divided by cost of goods sold. $\Delta SALES_t$ is measured as the year-over-year percentage change in sales. $ExtremePositive_{t-1}$ and $ExtremeNegative_{t-1}$ are indicator variables equal to 1 if a firm ranks in the top or bottom quintiles respectively of sales growth in year $(t - 1)$ and 0 otherwise. $WD_{t+1}$ is an indicator variable equal to 1 if a firm experiences a first time inventory write-down of at least 1% of total assets in period $(t + 1)$ and 0 otherwise. Standard errors are estimated using two-way clustering on firms and years. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level.
Table 9: Purchases scaled by cost of goods sold in \( t \) regressed on change in \( t \) sales, extreme growth indicators for \( t \) and write-down indicators for \((t + 1)\)

<table>
<thead>
<tr>
<th></th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \text{SALES}_t )</td>
<td>.074***</td>
<td>.148***</td>
<td>.148***</td>
</tr>
<tr>
<td></td>
<td>(.005)</td>
<td>(.025)</td>
<td>(.025)</td>
</tr>
<tr>
<td>( \Delta \text{SALES}_t \times \text{ExtremePositive}_t )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-.091***</td>
<td>-.091***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.025)</td>
<td>(.025)</td>
<td></td>
</tr>
<tr>
<td>( \Delta \text{SALES}_t \times \text{ExtremeNegative}_t )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.094***</td>
<td>.103***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.018)</td>
<td>(.016)</td>
<td></td>
</tr>
<tr>
<td>( \Delta \text{SALES}_t \times \text{ExtremePositive}<em>t \times \text{WD}</em>{t+1} )</td>
<td></td>
<td></td>
<td>.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(.010)</td>
</tr>
<tr>
<td>( \Delta \text{SALES}_t \times \text{ExtremeNegative}<em>t \times \text{WD}</em>{t+1} )</td>
<td></td>
<td></td>
<td>-.159***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(.028)</td>
</tr>
<tr>
<td>Const.</td>
<td>.997***</td>
<td>1.005***</td>
<td>1.005***</td>
</tr>
<tr>
<td></td>
<td>(.004)</td>
<td>(.002)</td>
<td>(.002)</td>
</tr>
<tr>
<td>Obs.</td>
<td>8386</td>
<td>8386</td>
<td>8386</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.129</td>
<td>.173</td>
<td>.175</td>
</tr>
</tbody>
</table>

Eq (C) \( \Delta \text{SALES}_t \times \text{ExtremePositive}_t + \Delta \text{SALES}_t \times \text{ExtremePositive}_{t-1} \times \text{WD}_{t+1} = 0 \) F-statistic=9.26, P-value=0.002

Sample consists of all non-financial and utility firm-years listed on either NYSE/NASDAQ/AMEX, CRSP and COMPUSTAT between 2002 and 2004 with inventory greater than 1% of average total assets and available data to calculate change in sales data for periods \((t - 1), t, \) and \((t + 1),\) and purchases to cost of goods sold in period \( t \). The dependent variable, \( \text{PURCHASES}_t / \text{COGS}_t \), is measured as purchases (ending inventory plus cost of goods sold minus beginning inventory) divided by cost of goods sold. \( \Delta \text{SALES}_t \) is measured as the year-over-year percentage change in sales. \( \Delta \text{SALES}_t \) is measured as the year-over-year percentage change in sales. \( \text{ExtremePositive}_t \) and \( \text{ExtremeNegative}_t \) are indicator variables equal to 1 if a firm ranks in the top or bottom quintiles respectively of sales growth in year \( t \) and 0 otherwise. \( \text{WD}_{t+1} \) is an indicator variable equal to 1 if a firm experiences a first time inventory write-down of at least 1% of total assets in period \((t + 1)\) and 0 otherwise. Standard errors are estimated using two-way clustering on firms and years. Standard errors are estimated using two-way clustering on firms and years. * Significant at the .10 level ** Significant at the .05 level *** Significant at the .01 level