On the relationship between inventory and financial performance in manufacturing companies

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Abstract

Purpose – The purpose of this paper is to study the relationship between inventory performance, both total inventory (INV) and its discrete components (raw material (RMI), work-in-process (WIP), and finished goods (FGI)), and financial performance in manufacturing companies.

Design/methodology/approach – Statistical analysis is applied to the financial information of US-based manufacturing firms over the 26-year period from 1980 to 2005.

Findings – The paper finds a significant positive correlation between inventory performance (total as well as the discrete components of inventory) and measures of financial performance (at both the gross and operating levels) for firms in manufacturing industries. The correlation between the performance of discrete types of inventory and financial performance varies significantly across inventory types. RMI performance has the highest correlation with all financial performance measures. Between WIP inventory and FGI performance, the former is more highly correlated with gross profit measures while the latter is more highly correlated with operating profit measures.

Originality/value – This paper is the first to systematically analyze the relationship between inventory performance and financial performance for a large sample of firms across all manufacturing industries. The paper adds to prior literature by discussing and testing the relationship between both INV performance and the discrete types of inventory (RMI, WIP, and FGI) and profitability of operations, both at the gross and at the operating profit levels. The paper also analyzes the results for firms across as well as within manufacturing industries. The results obtained support the operations management literature's claim that a managerial focus on inventory performance results in value creation for manufacturing firms.

Keywords Financial performance, Inventory, Process efficiency, Manufacturing industries

Paper type Research paper

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1. Introduction

The dominant theme of the operations management literature over the past century has been to improve operational performance. This can be achieved by reducing the lead time from raw materials to finished goods (faster cycle times), reducing the amount of waste in the process (managing the input and output quality), and by reducing the quantity of physical units held by the firm (working with suppliers and customers). Numerous techniques have been proposed to achieve this goal, including: business process reengineering, total quality management, supply chain integration, just-in-time (JIT), lean thinking, agile manufacturing, and activity-based management. The inherent logic of these techniques is self evident and widely accepted.

The majority of success stories in operations management stem from small sample research in the automotive, machinery, and job-shop (assembly) industries. These studies document increased market share, higher profitability and greater product quality for firms that have employed the above techniques to improve their operations. This paper aims to extend the evidence on the effects of improving inventory performance with a large sample study, an examination of total as well as the discrete components of inventory, in addition to an examination both across all manufacturing firms and within manufacturing industries.

We analyze the relationship between raw materials (RMI), work-in-process (WIP), finished goods (FGI), and total inventory (INV) performance (inventory performance) to the profitability of operating activities (financial performance) of US manufacturing firms in the 1980-2005 period. For the purpose of this study we use inventory levels scaled by sales as a measure of inventory performance. We find that improving a firm's inventory performance (lowering the inventory to sales ratio) yields better financial performance measured both at the gross profit and at the operating profit levels. Decomposing INV into its component parts (RMI, WIP, and FGI) reveals that the correlation is driven by all three discrete inventory types. The size of the correlation, however, varies significantly across inventory types and across financial performance measures. These results are consistent with and extend those of prior research, in particular that of Chen *et al.* (2005) and Shah and Shin (2007).

We further analyze the changes in inventory performance and financial performance over time (from 1980 through 2005) and find a decrease in INV levels scaled by sales (increase in inventory performance), consistent with Rajagopalan and Malhotra (2001) and Chen *et al.* (2005). However, the decomposition of INV into its component parts reveals that the main component of the decrease in INV is the reduction of the WIP inventory. This suggests that manufacturing firms' efforts to improve their production inventory performance is focused on WIP inventory. The change in financial performance measures was mixed over the 1980-2005 sample period. Regardless of the trend in either inventory performance or financial performance measures, the correlation between inventory performance and financial performance remains present across all inventory types and financial performance measures.

This study expands our knowledge of the relationship between firm level inventory and financial performance, which – as noted by Shah and Shin (2007) – "is not straight forward in the literature". First, prior research examining this relationship has been limited to small sample studies concentrated in a few manufacturing industries. By contrast, our paper uses a large sample of firms across all manufacturing industries. Second, due to the differential impact inventory performance might have on production and operating costs, we measure financial performance at both the gross and operating profit levels. Third, we incorporate the possibility raised by prior research that the sources, costs and benefits of inventory improvements could be very different (Balakrishnan *et al.*, 1996; Lieberman *et al.*, 1999; Lieberman and Demeester, 1999) by analyzing the inventory performance of the discrete components of inventory (RMI, WIP, and FGI), and their correlation with financial performance. To our knowledge, this is the first study to empirically test these relationships.

In addition to our main contributions noted above, we also analyze the cross-sectional and longitudinal correlations between inventory performance and financial performance, use a large sample of manufacturing firms and firm-level data over a longer time period[1], and offer an explanation for why better inventory performance should lead to better financial performance and increased firm valuation.

We proceed by presenting the relevant literature on the relationship between inventory performance and financial performance, as well as the related research on how operational methodologies have affected manufacturing firms since their introduction in the early 1980s. This discussion is followed by a description of the research questions, sample description, and applied methodologies. We conclude with a presentation of our key findings with their managerial implications.

2. Literature review

About half a century ago, Forrester's (1961) non-linear simulations on information and delivery delays in internal operations and supply chains helped academics and managers understand how information distortion and order batching lead to ever longer lead times and inventory build-up. Scale and cost-centric manufacturing dominated operations management until the 1970s when the quality movement turned the focus to continuous improvement and errorless operations.

JIT, and its emphasis on reducing waste, inventory reduction, and operational flexibility through a pull system, appeared in the early 1980s. Goldratt and Cox (1984) and Suri (1998) argued for a relentless reduction of bottlenecks and lead time. These approaches (that is, theory of constraints and quick response manufacturing) were based on flow and lead-time reduction and presented cases from job shops and machine assembly companies to support their claims. Other scholars and practitioners conveyed similar messages under different labels such as time-based competition (Stalk, 1988) and lean manufacturing (Womack *et al.*, 1990). Lead time reduction is often described in the operations management literature as arising from initiatives such as JIT/lean production or agility (Naylor *et al.*, 1999; Bartezzaghi *et al.*, 1995) rather than from identifying and reducing congestion at bottlenecks, reducing lot sizes, and moving to a product layout from a functional one. Koufteros *et al.* (1998) claim time-based manufacturing is related to shop-floor employee involvement, setup time reduction, cellular manufacturing, quality improvement efforts, preventive maintenance, dependable suppliers, and pull production, but do not relate these constructs to the principles that drive lead time. According to Schmenner (2001), companies that focus on flow with an emphasis on operational speed and variability reduction outperform companies emphasizing other goals. This conclusion is consistent with the principles of operations management, based on queuing theory, which demonstrates the relationships between lot sizes, cycle times, bottlenecks, lead times, and process variability (Hopp and Spearman, 2001; Schmenner and Swink, 1998).

Recent research on the relationship between a managerial focus on improving operations and performance has been concentrated primarily on JIT. Virtually all of this research has been carried out at the plant level, is case oriented with a small sample size, or is a narrow industry specific survey. The overwhelming majority of studies show the positive effect of JIT implementation on earnings and financial performance through the increase in productivity and inventory efficiency (Neil and O'Hara, 1987; Huson and Nanda, 1995; Lawrence and Hottenstein, 1995; Boyer, 1996; Fullerton *et al.*, 2003; Nahm *et al.*, 2003; Christensen *et al.*, 2005). Other studies like Callen *et al.* (2000) and Fullerton and McWatters (2001) provide support that JIT implementation improves firm performance through lower inventory levels, reduced quality costs, and greater customer responsiveness with higher profits. With only two exceptions (Balakrishnan *et al.*, 1996; Sakakibara *et al.*, 1997), these studies all contend that strategies aimed at increasing inventory performance (primarily through reduced inventory levels) are positively related to increases in value added defined as an increase in market share, sales, and profitability.

The lead time related research has focused principally on the automotive, machinery, and computer assembly operations. By contrast, supply chain research extends to all industries. The underlying emphasis in supply chain management is on information transparency, reliable lead times, and the clever positioning of various value-adding operations in long logistical chains. Hendricks and Singhal (2003) document that supply chain "glitch" announcements are associated with negative abnormal stock returns, observing that the impact is greater for smaller firms.

To date, the direct relationship between inventory performance and financial performance has been investigated only to a very limited extent. Claycomb *et al.* (1999) provide a model of the causal relationship between inventory and financial performance. Gaur *et al.* (2005) and Roumiantsev and Netessine (2007) both document a negative correlation between inventory performance and financial performance in the retail industry whose value proposition relates to efficient product availability. By contrast, the value proposition of the manufacturing industry is based primarily on value adding operations, product innovation and efficient order fulfillment. Chen *et al.* (2005) analyze the link between INV and long-term stock returns of manufacturing firms. They find that while firms with abnormally high inventory levels have poor long-term stock returns, firms with slightly lower than average inventory outperform firms with extremely low INV. Shah and Shin (2007) use aggregate sector data to show a link between inventory and profitability for the wholesale, retail, and manufacturing sectors. However, none of the above studies analyze the relationship between inventory performance and financial performance of manufacturing industries at the firm level, nor do they analyze the relationship between different financial performance measures with inventory performance. No study to date has examined the relationship between the inventory performance of the discrete components of inventory with financial performance. Our paper attempts to fill this gap.

The use of different measures of financial performance allows the analysis of both the level of profit above production costs (gross profit) as well as after operating expenses (operating profit). Including the performance of the discrete inventory components allows a test for any differential impacts on the costs of production and operating expenses (Palepu *et al.*, 2007, pp. 199-207, for an overview of financial performance measures).

Our paper is the first to look at the discrete components of inventory (RMI, WIP, and FGI) and their correlation with financial performance and we do this both at the firm level as well as for firms within specific industries. We build on prior research suggesting that sources of reduction, costs of reduction and benefits arising from the reduction in RMI, WIP, and FGI are very different. Hopp and Spearman (2001) indicate that RMI is determined by discounts, economies of scale, quality problems, changes in demand and supply, and obsolescence. WIP is determined by queuing, processing, waiting for batch, moving, and waiting to match. Finally, FGI is determined by customer responsiveness, batch production, forecast errors, production variability, and seasonality. For a description of differences between discrete inventory components (Krajewski and Ritzman, 2005; Heizer and Render, 2006). Lieberman *et al.* (1999) empirically analyze the sources of change in inventory of RMI, WIP, and FGI in the automotive industry. They find that all three discrete types of inventory depend on managerial actions, but in different ways. While formal methods to reduce inventory (like JIT) reduce WIP and FGI, they have no impact on the RMI. They also find that maintaining communication with suppliers and customers leads to reductions in RMI and FGI, with no impact on WIP inventory. The costs and benefits associated with the change may differ between inventory types since the sources of these changes are different. As Balakrishnan *et al.* (1996, p. 195) argue, "reducing WIP inventory requires less coordination with a firm's suppliers or customers than is required to reduce RMI or FGI and thus imposes fewer implementation costs". Balakrishnan *et al.* (1996) further argue that unlike reductions in RMI, reducing the WIP inventory does not require stability of the supply chain and that WIP holds the highest potential for improvement by reducing production lead time, reducing conversion costs and increasing manufacturing flexibility. Several studies show that implementation of JIT has a differential impact on discrete inventory types, with the reduction of WIP inventory present in all studies, but results for RMI and FGI remain mixed (Barton *et al.*, 1988; Norris *et al.*, 1994). Lieberman and Demeester (1999) suggest that a reduction in inventory (primarily WIP) increases productivity. Overall, prior research suggests that the costs associated with improving inventory performance are different across RMI, WIP, and FGI. Prior research also suggests that RMI and FGI will depend on supply management and the relationship with customers and that their main impact on performance comes from carrying costs. By contrast, WIP inventory depends on changes in production speed while its impact on financial performance comes from manufacturing flexibility, increased production activity and lower costs of production.

Recent research has begun to analyze the changes in the nature and level of inventory over time. Rajagopalan and Malhotra (2001) use aggregate industry data provided by the Census Bureau and find mixed results on the trends in INV and its components. By contrast, Chen *et al.* (2005) use firm-level RMI, WIP, and FGI data from the Compustat database and document a 16 per cent drop (from 96 to 81 days) in the average INV level (days of inventory) of all publicly-traded US manufacturing firms over the 20-year period from 1982 to 2000. Gaur *et al.* (2005) provide evidence of a reduction in inventory in the retail sector. Our results confirm the above findings and reveal that the improvement in INV over the 1980-2005 period comes primarily from improvements in WIP inventory performance and to a lesser extent RMI performance with no change in the FGI performance.

3. Research questions, sample selection, and methodology

The operations management literature indicates financial performance should be at least partially explained by inventory performance. Following the literature review we set our hypotheses as:

H1a. A firm's inventory performance will be positively correlated with the firm's financial performance.

H1b. The correlation between a firm's inventory performance and financial performance will be present across manufacturing industries.

H2a. The performance of all three discrete components of a firm's inventory (RMI, WIP, and FGI) will be positively correlated with the firm's financial performance.

H2b. The correlation between the performance of all three discrete components of a firm's inventory and the firm's financial performance will be present across manufacturing industries.

Prior literature indicates that a firm's strategic choice can simultaneously impact inventory and financial performance (Ketokivi and Schroeder, 2004; Mendelson and Parlakturk, 2008). For example, firms positioning themselves to provide their customers with high service levels may hold greater levels of inventory (both in quantity and variety), resulting in a positive correlation between inventory levels and financial performance. We control for this by using changes in (as opposed to levels of) inventory performance and financial performance. By looking at changes over time, a negative correlation between inventory and financial performance indicates that the effect exists over time between firms and within the same strategy. Firms can also change strategies (that is, decide to specialize their product line thereby reducing the number of products in their portfolio and their overall inventory). To control for this possibility, we analyze firms' improvements between two time periods and over the entire sample period separately thereby eliminating the potential impact of firms' decisions to change their strategic choice on our results.

Inventory performance and financial performance can also be influenced by sales surprises (Gaur *et al.*, 2005). More specifically, if a firm misses (beats) its sales target it will have a higher (lower) level of inventory and lower (higher) profit than projected. We control for this in two ways. First, we use both annual and quarterly data for inventory and financial performance over a 26-year period (for simplicity we present only annual data). The long time period reduces any potential impact of a sales surprise in a given year. Second, we analyze the time trend of both inventory performance and financial performance. A continual improvement is unlikely to result from a given year's incorrect sales forecast. Additionally, this effect is typical of firms in the retail industry (Gaur *et al.*, 2005), and is unlikely to impact our sample which is restricted to manufacturing firms.

The Compustat database is used both to retrieve the Standardized Industrial Classification (SIC) codes as well as to collect annual and quarterly financial report data. The SIC codes are used to restrict the sample to manufacturing firms (SIC codes 2000 to 3999) and to separate them by industry (Fama and French, 1997, industry classification). To compute the change in our variables (as defined below), we require at least two consecutive periods with financial reporting data and exclude data without a consecutive period. As proxies for financial performance, we use the following measures:

$$\mathrm{EBITS}_{j,t} = \frac{\mathrm{EBIT}_{j,t}}{\mathrm{Sales}_{j,t}}, \quad \mathrm{GPS}_{j,t} = \frac{\mathrm{Sales}_{j,t} - \mathrm{COGS}_{j,t}}{\mathrm{Sales}_{j,t}}$$

where EBIT is earnings before interests and taxes for firm j in year t, Sales are total sales for firm j in year t, and COGS is cost of goods sold for firm j in year t. Using both gross profit (GP) and EBIT allows us to analyze the determinants of financial performance on two levels. The GP reflects the added value as a difference between sales and the cost of production, while EBIT proxies for the profitability of the business after deducting all operating expenses, not only the production costs. Using either earnings before interests, taxes, depreciation and amortization (EBITDA) or net income after tax instead of EBIT does not change our results qualitatively. When scaled by sales, gross and operating profits represent gross and operating margin (profitability of firm's operations). Our results are qualitatively unchanged when we use an alternative financial performance measure equaling gross and operating profits scaled by total assets. These financial performance measures, as opposed to profitability of firm's operations, represent the return on invested assets (Palepu *et al.*, 2007, pp. 199-207).

Past literature provides us with several possible measures of inventory performance which include scaling inventory by cost of goods sold (Huson and Nanda, 1995), by combination of material costs and value added (Rajagopalan and Malhotra, 2001) and by sales (Chen *et al.*, 2005). Using any of these measure yields qualitatively unchanged results. To be consistent with financial performance measures, we scale inventory by sales:

$$\mathrm{RMIS}_{j,t} = \frac{\mathrm{avg}(\mathrm{RMI}_{j,t-1}, \mathrm{RMI}_{j,t})}{\mathrm{Sales}_{j,t}}, \quad \mathrm{WIPS}_{j,t} = \frac{\mathrm{avg}(\mathrm{WIP}_{j,t-1}, \mathrm{WIP}_{j,t})}{\mathrm{Sales}_{j,t}},$$

$$\mathrm{FGIS}_{j,t} = \frac{\mathrm{avg}(\mathrm{FGI}_{j,t-1}, \mathrm{FGI}_{j,t})}{\mathrm{Sales}_{j,t}}, \quad \mathrm{INVS}_{j,t} = \frac{\mathrm{avg}(\mathrm{INV}_{j,t-1}, \mathrm{INV}_{j,t})}{\mathrm{Sales}_{j,t}}$$

where RMIS is the performance of RMI for firm j in year t, WIPS is the performance of WIP inventory, FGIS is the performance of FGI, INVS is the performance of INV. Sales are total sales of firm j for year t. Avg is the arithmetic average of inventory levels at the beginning and the end of the year t. These inventory performance measures are used throughout the paper in all tables, results and discussions.

We derive a model similar to Shah and Shin (2007) to test for the relationship between our financial performance and inventory performance measures. The following levels specification models are estimated:

$$\mathrm{EBITS}_{j,t} = \alpha + \beta_1 \mathrm{EBITS}_{j,t-1} + \beta_2 \mathrm{Size}_{j,t} + \beta_3 S_{j,t} + \sum_t \mathrm{Ind}_k + \sum_t \mathrm{Year}_k + \varepsilon \quad (1)$$

$$\mathrm{GPS}_{j,t} = \alpha + \beta_1 \mathrm{GPS}_{j,t-1} + \beta_2 \mathrm{Size}_{j,t} + \beta_3 S_{j,t} + \sum_t \mathrm{Ind}_k + \sum_t \mathrm{Year}_k + \varepsilon \quad (2)$$

EBITS is operating profit scaled by sales, GPS is the gross profit scaled by sales. Size is the natural log of inflation adjusted total assets. S is the inventory performance measure for INVS, RMIS, WIPS, or FGIS. Ind is the set of industry dummy variables and Year is the set of year dummy variables. We further estimate regression models that take into account all three-inventory types as follows:

$$\text{EBITS}_{j,t} = \alpha + \beta_1\text{EBITS}_{j,t-1} + \beta_2\text{Size}_{j,t} + \beta_3\text{RMIS}_{j,t} + \beta_4\text{WIPS}_{j,t} + \beta_5\text{FGIS}_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (3)$$

$$\text{GPS}_{j,t} = \alpha + \beta_1\text{GPS}_{j,t-1} + \beta_2\text{Size}_{j,t} + \beta_3\text{RMIS}_{j,t} + \beta_4\text{WIPS}_{j,t} + \beta_5\text{FGIS}_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (4)$$

We expect all inventory performance measures to have negative and statistically significant coefficients. The less inventory a firm requires per unit of sales, the greater its financial performance (all else equal). We expect this result to hold across inventory types (RMI, WIP, and FGI) and across industries. We also expect the result to hold for both, operating financial performance (EBIT) and gross financial performance (GP). Finally, we expect positive and statistically significant coefficients associated with the lagged financial performance variables (autocorrelation), consistent with the halo effect. The halo effect is the effect where past financial performance significantly affects current performance (Sine *et al.*, 2003). We control for the size effect, but make no predictions about the sign or significance of the coefficient, since the size effect depends largely on the industry, cycle and performance measures used (Chan *et al.*, 1985; Chan and Chen, 1988).

Next, we re-estimate the above regressions using change specification models instead of the above levels specification. We analyze the impact of the changes in inventory performance measures on changes in financial performance measures using the following regression models:

$$\Delta\text{EBITS}_{j,t} = \alpha + \beta_1\Delta\text{EBITS}_{j,t-1} + \beta_2\text{Size}_{j,t}\beta_3\Delta S_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (5)$$

$$\Delta\text{GPS}_{j,t} = \alpha + \beta_1\Delta\text{GPS}_{j,t-1} + \beta_2\text{Size}_{j,t} + \beta_3\Delta S_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (6)$$

$$\Delta\text{EBITS}_{j,t} = \alpha + \beta_1\Delta\text{EBITS}_{j,t-1} + \beta_2\text{Size}_{j,t} + \beta_3\Delta\text{RMIS}_{j,t} + \beta_4\Delta\text{WIPS}_{j,t} + \beta_5\Delta\text{FGIS}_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (7)$$

$$\Delta\text{GPS}_{j,t} = \alpha + \beta_1\Delta\text{GPS}_{j,t-1} + \beta_2\text{Size}_{j,t} + \beta_3\Delta\text{RMIS}_{j,t} + \beta_4\Delta\text{WIPS}_{j,t} + \beta_5\Delta\text{FGIS}_{j,t} + \sum_t \text{Ind}_k + \sum_t \text{Year}_k + \varepsilon \quad (8)$$

We expect the changes in inventory performance to be negatively associated with the changes in financial performance, across inventory types and industries. In addition, we expect the coefficient associated with the lagged financial performance measures to be negative and statistically significant indicating a mean reversion of changes in financial performance.

All the above regressions are estimated using ordinary least square (OLS), with year and industry fixed effects. As robustness checks, we control for firm fixed effects (using fixed effects regressions) and random effects (using random effects regressions) and also use the Fama-MacBeth regressions (Fama and MacBeth, 1973). All these alternative methods (omitted from the presentation) support the results of our OLS regressions.

4. Empirical analysis, results and discussion

To test whether better inventory performance is positively correlated with better financial performance, we create a sample of US manufacturing firms (with SIC codes from 2000 to 3999) from the Compustat database for the 1980-2005 period. We exclude all firm-year observations without data available on RMI, WIP inventory, or FGI. We also exclude all firm-year observations with data unavailable on sales, cost of goods sold or total assets. Panel A of Table I shows the descriptive statistics for our firm-year sample of all US manufacturing firms, containing 52,254 observations. The descriptive statistics show all observations found in the Compustat database, winsorized at the 1 percent level, for all firm-year available variables. Panel B of Table I shows median values for the full sample of all US manufacturing firms over the 1980-2005 period. Our financial performance measures show a mixed trend with median EBITS (operating profit) decreasing, and median GPS (gross profit) increasing over the sample period. Consistent with prior studies on changes in inventory performance (Rajagopalan and Malhotra, 2001; Chen *et al.*, 2005) we also find an increase in the inventory performance of RMI and WIP inventory. There is no increase in FGI performance. The increase is most prevalent in WIP inventory where the performance has doubled.

We present our levels specification regressions results (equations (1)-(4)) in Table II. As hypothesized, the coefficients associated with all four-inventory performance variables are negative and statistically significant in all regressions. Our results indicate better inventory performance (a lower inventory-to-sales ratio) is positively associated with the profitability of a firm's operations. Inventory performance is positively associated with financial performance measures at both the gross and operating profit levels. The regression estimates also reveal that inventory performance is positively related to financial performance regardless of the inventory type (RMI, WIP, or FGI). Differences in the strength of the correlation, however, exist between discrete inventory types. The RMI performance exhibits the strongest correlation with financial performance across all financial measures. The WIP performance has a stronger correlation with gross financial performance, while FGI has a stronger correlation with operating financial performance. The differences between coefficients associated with RMI, WIP, and FGI performance variables are all statistically significant. The lagged financial performance measure, as expected, has a high positive and statistically significant coefficient indicating a high level of autocorrelation. Relaxing this assumption and removing the lagged financial performance measure from the regression does not change our results qualitatively. The coefficients associated with all inventory performance variables stay statistically significant while the R^2 of the regressions decrease, on average, by half. The size coefficient is positive and significant across all regression models.

The results of our changes specification regressions (equations (5)-(8)) are presented in Table III and support the levels specification models' results. Firms that decrease inventory relative to sales increase both gross profit and operating profit, consistent with our hypotheses. All coefficients associated with our inventory performance measures (ΔRMIS, ΔWIPS, ΔFGIS, and ΔINVS) are negative and statistically significant.

Table I.
Descriptive statistics

Panel A	*N*	*Mean*	*SD*	*Minimum*	*p25*	*Median*	*p75*	*Maximum*
Total assets (1980 $ million)	52,254	555.16	2,713.03	0.01	9.78	39.55	189.14	100135.00
Sales (1980 $ million)	52,254	528.15	23,39.64	0.00	10.6	46.75	214.66	77,862.13
EBITS	52,254	−14.68%	113.43%	−1197.73%	−0.90%	6.02%	11.04%	32.42%
GPS	52,254	32.77%	35.45%	−303.63%	23.71%	34.20%	47.53%	82.15%
RMIS	52,254	7.56%	7.09%	0.07%	3.32%	5.66%	9.27%	45.52%
WIPS	52,254	4.79%	6.01%	0.00%	1.02%	2.94%	6.14%	35.68%
FGIS	52,254	7.32%	6.90%	0.00%	2.70%	5.59%	9.67%	40.18%
INVS	52,254	19.92%	14.47%	2.82%	11.37%	16.62%	23.95%	98.85%
Panel B – changes in medians over the 1980-2005 period								
Year	*EBITS (%)*	*GPS (%)*	*RMIS (%)*	*WIPS (%)*	*FGIS (%)*	*INVS (%)*	*N*	
1980	7.54	29.51	6.53	4.14	5.68	19.27	1,555	
1981	7.41	30.91	6.62	4.20	5.63	19.15	1,569	
1982	5.85	31.40	6.63	4.39	6.25	20.00	1,554	
1983	6.36	32.23	6.51	4.37	6.03	19.41	1,707	
1984	6.66	32.71	6.32	4.26	5.73	18.70	1,754	
1985	5.67	32.63	6.38	4.17	5.81	18.99	1,770	
1986	5.51	33.50	6.24	4.00	5.99	18.73	1,839	
1987	6.00	33.41	5.96	3.75	5.77	18.12	1,919	
1988	6.00	33.48	6.07	3.63	5.70	17.71	1,902	
1989	5.85	32.97	5.94	3.50	5.73	17.56	1,845	
1990	5.56	33.48	5.81	3.32	5.64	17.26	1,838	
1991	5.07	34.70	5.70	3.17	5.80	17.10	1,880	
1992	5.63	34.71	5.38	2.99	5.61	16.30	1,948	
1993	6.05	34.86	5.37	2.79	5.49	15.86	2,100	
1994	7.00	34.33	5.24	2.66	5.23	15.17	2,216	
1995	7.30	35.30	5.40	2.69	5.19	15.37	2,336	

(*continued*)

1996	7.25	35.66	5.51	2.69	5.15	15.41	2,539
1997	7.07	35.49	5.41	2.53	5.36	15.78	2,546
1998	6.44	35.21	5.43	2.51	5.53	16.14	2,392
1999	5.99	35.85	5.51	2.38	5.62	15.85	2,365
2000	5.74	35.83	5.49	2.20	5.57	15.59	2,279
2001	3.32	34.67	5.55	2.32	6.03	16.51	2,203
2002	3.87	35.54	5.20	2.14	6.05	15.90	2,103
2003	4.35	36.16	4.69	1.89	5.57	14.64	2,078
2004	5.73	36.68	4.61	1.87	5.20	13.84	2,051
2005	5.95	36.42	4.73	1.84	5.12	13.99	1,966

Notes: Sample of 52,254 firm-year observations of US manufacturing firms for the 1980-2005 period. Data were collected from the Compustat database. EBITS is earnings before interests and taxes scaled by sales. GPS is the difference between sales and cost of goods sold scaled by sales. RMIS is the performance of RMI, WIPS is the performance of WIP and FGIS is the performance FGI, all scaled by sales

Table I.

Panel A			*EBITS*		
Lagged EBITS	0.585***	0.596***	0.648***	0.631***	0.581***
	(42.012)	(42.351)	(44.453)	(43.747)	(41.659)
Size	0.013***	0.003**	0.030***	0.032***	0.007***
	(8.829)	(2.207)	(16.549)	(17.667)	(4.213)
INVS	−1.933***				
	(24.229)				
RMIS		−3.653***			−3.082***
		(22.788)			(21.344)
WIPS			−1.882***		−1.032***
			(12.759)		(8.199)
FGIS				−2.348***	−1.611***
				(17.853)	(14.700)
Constant	0.241***	0.220***	−0.073***	0.038**	0.298***
	(13.255)	(12.094)	(4.728)	(2.372)	(15.051)
Industry controls	Included	Included	Included	Included	Included
Year controls	Included	Included	Included	Included	Included
N	52,043	52,043	52,043	52,043	52,043
F	99.418	96.483	86.693	89.000	97.735
Prob > *F*	0.000	0.000	0.000	0.000	0.000
R^2	0.637	0.628	0.595	0.605	0.640
Adjusted R^2	0.637	0.628	0.595	0.605	0.640
Panel B			*GPS*		
Lagged GPS	0.636***	0.634***	0.656***	0.658***	0.631***
	(40.906)	(40.794)	(41.798)	(42.120)	(40.581)
Size	0.003***	0.000	0.006***	0.007***	0.001
	(5.554)	(0.793)	(11.944)	(12.370)	(1.247)
INVS	−0.351***				
	(14.610)				
RMIS		−0.745***			−0.661***
		(15.118)			(14.285)
WIPS			−0.426***		−0.250***
			(9.862)		(6.403)
FGIS				−0.324***	−0.137***
				(8.430)	(4.076)
Constant	0.140***	0.144***	0.077***	0.088***	0.152***
	(19.465)	(19.630)	(12.450)	(14.205)	(19.801)
Industry controls	Included	Included	Included	Included	Included
Year controls	Included	Included	Included	Included	Included
N	52,046	52,046	52,046	52,046	52,046
F	440.047	464.339	487.432	456.774	442.877
Prob > *F*	0.000	0.000	0.000	0.000	0.000
R^2	0.554	0.555	0.541	0.540	0.557
Adjusted R^2	0.554	0.554	0.541	0.540	0.556

Notes: *, **, and *** represent statistically significant coefficients at the 10, 5 and 1 percent levels, respectively. OLS regression models of financial performance (EBITS and GPS). Sample of 52,254 firm-year observations of US manufacturing firms for the 1980-2005 period. Data were collected from the Compustat database. EBITS is earnings before interests and taxes scaled by sales. GPS is gross profit (the difference between sales and cost of goods sold) scaled by sales. INVS is the performance of INV, RMIS is the performance of RMI, WIPS is the performance of WIP inventory and FGIS is the performance of FGI, all scaled by sales

Table II.
Levels specification regressions

Panel A			ΔEBITS		
Lagged ΔEBITS	0.044***	0.037**	0.034*	0.039**	0.043***
	(2.701)	(2.281)	(1.809)	(2.151)	(2.705)
Size	−0.008***	−0.008***	−0.008***	−0.008***	−0.008***
	(8.382)	(8.425)	(7.534)	(7.970)	(8.631)
ΔINVS	−2.963***				
	(42.362)				
ΔRMIS		−6.018***			−4.559***
		(39.227)			(28.126)
ΔWIPS			−5.317***		−1.713***
			(27.245)		(9.552)
ΔFGIS				−5.043***	−2.336***
				(31.383)	(15.578)
Constant	0.024***	0.013*	0.028***	0.034***	0.021***
	(3.204)	(1.694)	(3.385)	(4.075)	(2.712)
Industry controls	Included	Included	Included	Included	Included
Year controls	Included	Included	Included	Included	Included
N	45,657	45,657	45,657	45,657	45,657
F	38.340	33.771	18.404	21.834	39.043
Prob > *F*	0.000	0.000	0.000	0.000	0.000
R^2	0.287	0.255	0.103	0.151	0.290
Adjusted R^2	0.286	0.254	0.102	0.150	0.289
Panel B			*ΔGPS*		
Lagged ΔGPS	−0.063***	−0.068***	−0.066***	−0.066***	−0.065***
	(3.808)	(4.119)	(3.762)	(3.803)	(3.971)
Size	−0.001***	−0.001***	−0.001***	−0.001***	−0.001***
	(4.734)	(4.838)	(4.652)	(4.812)	(4.897)
ΔINVS	−0.559***				
	(26.924)				
ΔRMIS		−1.168***			−0.913***
		(25.847)			(18.780)
ΔWIPS			−1.068***		−0.394***
			(18.969)		(7.140)
ΔFGIS				−0.896***	−0.341***
				(20.146)	(7.712)
Constant	0.010***	0.008***	0.011***	0.012***	0.009***
	(3.472)	(2.676)	(3.659)	(4.008)	(3.145)
Industry controls	Included	Included	Included	Included	Included
Year controls	Included	Included	Included	Included	Included
N	45,659	45,659	45,659	45,659	45,659
F	16.800	16.132	10.200	10.455	17.119
Prob > *F*	0.000	0.000	0.000	0.000	0.000
R^2	0.114	0.107	0.050	0.057	0.118
Adjusted R^2	0.113	0.106	0.049	0.056	0.117

Notes: *, **, and *** represent statistically significant coefficients at the 10, 5, and 1 percent levels, respectively. OLS regression models of changes in financial performance (EBITS and GPS). Sample of 52,254 firm-year observations of US manufacturing firms for the 1980-2005 period. Data were collected from the Compustat database. EBITS is earnings before interests and taxes scaled by sales. GPS is gross profit (the difference between sales and cost of goods sold) scaled by sales. INVS is the performance of INV, RMIS is the performance of RMI, WIPS is the performance of WIP inventory and FGIS is the performance of FGI, all scaled by sales

Table III.
Changes specification regressions

Consistent with our levels specification regressions, the change in RMI performance has the highest coefficient indicating the highest association with the change in financial performance across all models. The change in WIP inventory performance has a stronger correlation with the change in gross financial performance measures than the change in FGI performance. This relationship reverses in the operating financial performance regression models. All differences in coefficients are statistically significant. The coefficient associated with the lag change in financial performance is negative and statistically significant indicating a mean reversion for gross profit scaled by sales. However, the coefficient is positive and statistically significant for operating profit scaled by sales[2]. The coefficient associated with the size variable is negative and statistically significant across all regression models.

Finally, we separately analyze the manufacturing industries using the regression model from equation (1). Table IV shows these results for the EBITS financial performance measure. The relationship between inventory (RMI, WIP, and FGI) performance and financial performance is present in most industries. The lower the inventory per sales dollar, the greater the operating profit. This relationship holds in un-tabulated results for most industries using any of the regression models discussed in this study. The impact of different types of inventory (RMI, WIP, or FGI) on operating profit varies significantly and predictably between industries. In assembly industries, like automobiles, machinery, and computers, the reduction of all inventories improves operating profit. As our prior analysis shows, the reduction in WIP drives the reduction in FGI, which in turn allows firms to be more reactive. This is especially true for industries producing short life-cycle products like electronic equipment, in which components, production facilities and products tend to have ever shorter life-spans. This also applies, to a lesser extent, in high-tech industries like medical equipment and instruments.

By contrast, the above result is not as evident in basic commodities and process industries where relatively cheap RMI and WIP will not play as important a role on operating profit. However, a production process which satisfies demand efficiently with a low FGI does have a strong impact on operating profits. This also applies to textiles and other fashion industries where products, once in the market, need to be consumed rapidly before they lose their attractiveness.

5. Conclusion

We analyze the relationship between inventory performance, both INV and its discrete components (RMI, WIP, and FGI), and financial performance using a large sample study of US-based manufacturing firms over the 26-year period from 1980 to 2005. Our results show a strong correlation between inventory performance and financial performance across a broad array of manufacturing industries. Performance of total as well as all three discrete components of inventory is positively associated with financial performance. However, the strength of the correlation differs between inventory types. FGI performance has the strongest correlation with financial performance. Between WIP and FGI performance, WIP inventory performance has a stronger correlation with the GP measures of financial performance, while finished good inventory performance has a stronger correlation with operating profit measures of financial performance. Our results support the operations management literature's claim that a managerial focus on operations performance – in particular increases in inventory performance – correlates with significant value creation.

	Lagged EBITS	Size	WIPS	RMIS	FGIS	Constant	N
Food products	0.732***	0.015***	0.934	−4.590***	−0.578***	0.182***	1722
Candy and soda	0.349***	−0.045***	12.785***	−6.648***	−8.406***	0.751***	307
Beer and liquor	0.571***	0.025***	0.237	0.279	−0.034	−0.127***	418
Tobacco products	0.326***	0.029***	0.766**	0.257	−0.352*	−0.101**	132
Recreation	0.718***	0.018*	−4.125***	−2.071***	−0.707***	0.209***	996
Printing and publishing	0.187***	0.017***	−0.814***	−0.326**	−0.221***	0.026**	764
Consumer goods	0.743***	0.012**	−1.129***	−0.825***	−0.737***	0.097***	2316
Apparel	0.605***	0.023***	−1.745***	−0.345*	−0.907***	0.106***	1848
Medical equipment	0.528***	0.010	−2.866***	−4.035***	−2.753***	0.602***	3907
Pharmaceutical products	0.512***	0.005	−1.368***	−8.636***	−3.310***	0.702***	3014
Chemicals	0.589***	0.018***	−1.161***	−4.157***	−0.584**	0.208***	2036
Rubber and plastic products	0.635***	0.005	1.227***	−2.405***	−0.851***	0.161***	1629
Textiles	0.697***	0.006***	−0.134***	−0.381***	−0.112***	0.021***	1125
Construction materials	0.672***	0.004	−0.415*	−2.582***	−1.144***	0.241***	2871
Steel works	0.788***	0.016***	0.085	−1.007***	−1.227***	0.069**	1708
Fabricated products	0.265***	0.021***	−0.444***	−0.015	−0.275**	−0.014	612
Machinery	0.537***	0.020***	−0.852***	−1.737***	−0.400***	0.141***	4384
Electrical equipment	0.616***	−0.007	−0.773***	−2.797***	−1.178***	0.371***	2337
Automobiles and trucks	0.400***	0.017***	0.227*	−0.587***	−0.808***	0.013	1936
Aircraft	0.650***	0.001	0.205	−1.105***	0.379	0.055	592
Shipbuilding, railroad equipment	0.517***	0.019	−1.312***	−1.037*	0.429	0.054	296
Defense	0.241***	−0.012	0.029	−2.587***	−0.194	0.223***	128
Computers	0.483***	0.001	−3.047***	−2.753***	−3.598***	0.513***	4060
Electronic equipment	0.558***	0.001	−0.631***	−2.348***	−1.590***	0.271***	7513
Measuring and control equipment	0.578***	0.008	−1.561***	−3.431***	−2.366***	0.511***	3366
Business supplies	0.475***	0.005*	−2.087***	−0.979***	−0.638***	0.139***	1660
Shipping containers	0.302***	0.007	−1.439	−12.476***	−2.057***	0.747***	366

Notes: *, **, and *** represent statistically significant coefficients at the 10, 5, and 1 percent levels, respectively. OLS regression models of financial performance (EBITS) per Fama and French (1997) industry classification. Sample of 52,254 firm-year observations of US manufacturing firms for the 1980-2005 period. Data were collected from the Compustat database. EBITS is earnings before interests and taxes scaled by sales. RMIS is the performance of RMI, WIPS is the performance of WIP inventory and FGIS is the performance of FGI, all scaled by sales. N is the number of observations

Table IV. Industry analysis

Our results are based on correlations and do not prove causality between our variables. Furthermore, this paper is limited to data available in public databases and includes only publicly listed manufacturing US firms over the 1980-2005 sample period. While our sample consists of a large number of firms that are representative of the US economy, the conclusions of this paper should not be generalized beyond its scope. The collected data are for the firm as a single entity, and do not account for the complexity of firms that operate in more than one manufacturing facility. The data used in this paper are reported by firms and as such are a result of reporting incentives and accounting choices made, which make them noisy compared to case studies and surveys. Financial performance and inventory performance measures and resulting findings used in this paper should be interpreted accordingly. However, prior literature has documented many positive turnarounds in manufacturing companies through the reduction of inventories and faster operations. Our statistical analysis further supports the hypothesis of a causal relationship between inventory performance and financial performance.

For everyday managers of manufacturing companies, the underlying message of this paper is directly linked with both the short- and long-term performance of their enterprise. The statistical analysis indicates that in most industries inventory performance may be a decisive strategic factor where firms which do not focus on inventory performance underperform their competitors. While our results show a positive correlation between all the inventory components and improved financial performance, managers should probably focus their efforts on reducing RMI where the relationship is the strongest. When setting up development projects in manufacturing firms, supplier relationships and partnering appear to be important issues along with the organization of the value adding operations inside the company. This, naturally, does not play down the importance of accessing reliable and real time market information.

Notes

1. Compared to previous studies using aggregate sector data (Rajagopalan and Malhotra, 2001; Shah and Shin, 2007).
2. Winsorizing this variable at 2 percent instead of 1 percent would yield the opposite (negative) sign and a statistically significant coefficient.

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