Linking Inventory Management Performance and Operational Performance: An Empirical Analysis of U.S. Fashion Apparel and Accessory Industries

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Abstract Managing inventories is at the core of operational performance in fashion industries. Due to its importance in practice, inventory management has been a well-studied area of research in operations management. The purpose of this study is to examine the relationship between inventory management performance including inventory efficiency, productivity and responsive, and firm operational performance. We present and empirically test a performance model which integrates the various dimensions of a fashion industry's inventory management execution. The regression analysis is used to study the effect of various measures on inventory performance. We use financial data for 40 publicly listed U.S. fashion apparel and accessory industries for the 6-year period, 2010–2015, from "Compustat North America Annually Updated" available at Standard and Poor's Compustat database using Wharton Research Data Services (WRDS). We discuss the implications of these empirical results on the study of inventory policy execution, and propose some guidance for further research.

Keywords Inventory management · Fashion apparel industry · Operations management · Operational performance · Inventory efficiency · Inventory productivity · Inventory responsiveness

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1 Introduction

A longitudinal approach to examining inventory management performance is important to understand fashion apparel and accessory firm competitive performance. In this paper we explore the relationship between the inventory management of U.S. fashion apparel and accessory firms and competitive operational performance advantages. Some research has identified a number of firm-level inventory management issues in retailing, such as industry competitiveness, gross margin, capital investment intensity and sales surprise (Fisher and Raman 2001; Olivares and Cachon 2009; Gaur et al. 1999, 2005; Eroglu and Hofer 2011; Rajagopalan 2012; Hancerliogullari et al. 2016). The objective of this paper to show and empirically test a comprehensive performance model that incorporates the different dimensions of a fashion firm's inventory management execution including efficiency, productivity and responsiveness in order to evaluate the inventory management performance effect on firm competitive outperformance. By applying our model to fashion apparel and accessory industry, we expect to build on previous literature supporting a more scientific understanding of firm performance benchmarking and evaluation in this distinctive sector (Fisher and Raman 2010).

2 Data Description and Definition of Variables

We obtained the financial data for all publicly listed U.S. fashion apparel and accessory industries for the 6-year period 2010–2015 from "Compustat North America Annually Updated" available at Standard & Poor's Compustat database using Wharton Research Data Services (WRDS). The U.S. Department of Commerce assigns a Standard Industry Classification (SIC) code to each firm according to its primary industry segment. We group together firms in similar product groups as there are substantial overlaps among their products. For example, all firms with SIC codes between 5600–5699 are collected in a segment called "Fashion apparel and accessory industries". The categorization that we use is the similar as that was used in Gaur et al. (2005). Table 1 summarizes the segment, corresponding SIC codes, and a few examples of firms in each category. The original data set contained

Table 1 Classification of the U.S. fashion apparel and accessory industries

Industry name	SIC codes	Examples of firms
Apparel and accessory stores	5600	Claire's, burlington stores, american eagle outfitters
Womens' clothing stores	5621	Charming shoppes, coldwater creek, New York & Co
Family clothing stores	5651	Gap, nordstrom, ross stores, TJX companies
Shoe stores	5661	Foot locker, DSW, finish line

290 annual observations across 57 firms. We omit from our data set the firms that have less than five consecutive years of data. Our final data set contains 234 annual observations across 40 firms for the period 2010–2015.

2.1 Model Variables

Operations Management literature proposes that inventory efficiency, gross margin productivity and responsiveness are positively correlated with firm's operational performance. However, it is unclear how to link this to fashion industries' firm productivity performance. By applying the model provided in Shockley and Turner (2015) to U.S. fashion apparel and accessory industries, we hope to build on existing literature. For purposes of our study, we used the following model variables; their COMPUSTAT code and definitions are provided in Table 2.

2.2 Inventory Policy Performance Variables

We use three metrics as proxies to measure the different inventory performance dimensions, inventory policy performance variables and their calculations are provided in Table 3.

Table 2 Definition of model variables

Variables	COMPUSTAT code	Definition
Inv_{it}	INVT	Inventories-total
S_{it}	SALE	Sales/turnover (net)
$COGS_{it}$	COGS	Cost of goods sold
AT_{it}	AT	Assets-total
$LIFO_{it}$	LIFR	LIFO reserve
$EBITDA_{it}$	EBITDA	Earnings before interest
PPE_{it}	PPENT	Property, plant and equipment-total (net)

Table 3 Definition of inventory policy performance variables

Inventory measures	Calculations
Inventory efficiency (inventory/COGS ratio)	$XI_{it} = \frac{Inv_{it}}{COGS_{it}}$
Gross margin return on inventory investment	$GMROII_{it} = \frac{GM_{it}}{Inv_{it}}$
Inventory responsiveness (co-movements of inventory and COGS)	$XC_{it} = \frac{\mathrm{Inv_{it}} - \mathrm{Inv_{i(t-1)}}}{\mathrm{Inv_{i(t-1)}}} - \frac{\mathrm{COGS_{it}} - \mathrm{COGS_{i(t-1)}}}{\mathrm{COGS_{i(t-1)}}}$
Inventory responsiveness (over-responsiveness)	$XC+_{it} = XC_{it} \times 1_{(IR \geq 0)}$
Inventory responsiveness (under-responsiveness)	$XC-_{it} = XC_{it} \times -1_{(IR \geq 0)}$

Relative inventory level (XI): Measures the total average inventory over cost of goods sold and is the inverse of inventory turnover. It is a common performance indicator reflecting inventory efficiency and leanness.

Gross margin return on inventory investment (GMROII): Measures how much profit contribution a firm earns on every dollar it spends on inventory. It evaluates the profit-productivity of the inventory sold.

Inventory responsiveness (XC): Measures the responsiveness of the firm in matching customer sales with the inventory held by the firm over the annual period. Two measures (XC^{+}, XC^{-}) specify how quickly a firm adjusts inventory levels in response to annual changes in the sales environment.

We made several transformations to conduct our analysis including that every balance sheet item was adjusted to get an average value for that item for each firm for the annual period. For instance, the inventory measure used in each variable was calculated based on averaging the prior year period-ending inventory ($Inv_{i(t-1)}$) and the current year (Inv_{it}) period-ending inventory balances (adjusted for the LIFO reserve). Similarly, same procedure was done for the cost of goods sold and gross margin are adjusted for the LIFO reserve as stated. Table 4 shows the descriptive statistics for each industry for the performance variables. We see that there is a great level of variation in inventory (minimum average at 205,185 in womens' clothing and maximum average at 609,715 in family clothing) across different segments of the fashion industry.

2.3 Firm and Segment Control Variables

In order to manage total inventories, total capital investment and sales growth for each firm are also controlled. Existing research has stated the importance of capital investment variable when evaluating inventory and operational performance

Table 4 Summary statistics of the inventory performance variables

Industry	SIC codes	# of firms	# of observations	Avg. annual sales ($ mil.)	Avg. inventory	Avg. XI	Avg. GMROII	Avg. XC
Apparel and accessory stores	5600	6	35	1772,552	254,317	0,232	0,003	0,036
Womens' clothing stores	5621	13	75	2035,592	205,185	0,191	0,008	0,014
Family clothing stores	5651	16	94	4891,776	609,715	0,294	0,005	0,031
Shoe stores	5661	5	30	2507,658	489,861	0,338	0,001	0,001
All		40	234	3204,126	411,534	0,257	0,005	0,022

Table 5 Definition of control variables

Control variables	Calculations
Capital investment (firm operational capital)	$K_{it} = log\left[PPE_{it} + \sum_{\tau=1}^{5} \frac{LC_{it}}{1+r^{\tau}}\right]$
Sales growth rate (firm revenue growth)	$\Delta S_{it} = [S_{it} - S_{i,t-1}]/S_{i,t-1}$
Relative gross margin (firm vs. segment avg.)	$GM\%_{it} = \frac{S_{it} - COGS_{it}}{S_{it}}$ $rGM_{it} = GM_{it} - GM_{seg,t}$
Relative sales over fixed assets (firm vs. segment avg.)	$SOA_{it} = S_{it}/(AT_{it} - Inv_{it})$ $rSOA_{it} = SOA_{it} - SOA_{seg,t}$

(Kesavan et al. 2010; Eroglu and Hofer 2011; Hancerliogullari et al. 2016). As being discussed in the literature, K_{it} is the firm's total capital investment, the log of the sum total of total property, plant and equipment and the net present value of five-year lease contracts (operating leases) using the notation $LC_{it,1}(MRC1), \ldots, LC_{it,5}(MRC5)$ in COMPUSTAT while the weighted average cost of capital of the fashion industry (r = 8.25%) reported from Value Line as the annual discount rate.

Firm's revenue sales growth should be correlated with greater operating performance in fashion industry; therefore, fashion analysts focus on store growth and store sales growth. ΔS_{it} is the revenue sales growth of the fashion company in period t from period t−1. Moreover, Gaur et al. (2005) and Kesavan et al. (2010) indicate that controlling the gross margin of the product portfolio and the non-inventory fixed-asset performance of the firms is important. Therefore, segment-adjusted gross margin, rGM_{it}, and segment-adjusted non-inventory fixed assets, $rSOA_{it}$, are used as additional control variables. These variables and their calculations are summarized in Table 5.

2.4 Dependent Variables

As dependent variables, we use both the firm's segment adjusted return on assets (rROA) and return on sales (rROS) to measure performance. ROA is defined as earnings before interest generated per dollar of total asset investment. On the other hand, ROS is the earnings before interest generated for every dollar in annual sales. The correlation matrix is listed in Table 6.

Table 6 Correlation matrix of key model variables

	rROA	rROS	XI	GMROII	XC^+	XC^-	**ΔS**	rGM	rSOA
rROA	1								
rROS	0.91*	1							
XI	−0.22*	−0.20*	1						
GMROII	0.13	−0.05	−0.05	1					
XC^+	−0.10	−0.06	0.27*	0.04	1				
XC^-	0.10	0.06	−0.27*	−0.04	−1*	1			
ΔS	0.59*	0.54*	−0.05	0.17*	−0.13	0.13*	1		
rGM	0.27*	0.31*	0.34*	0.16*	−0.06	0.06	0.32*	1	
rSOA	0.04	−0.23*	0.07	0.09	−0.01	0.01	−0.00	−0.22	1

*$p < 0.05$

3 Hypothesis Development and Model Specification

In order to demonstrate how individual fashion apparel and accessory firms manage inventory responsiveness, inventory gross margin productivity and inventory leanness in various ways for competitive advantage, we present three hypotheses, which were presented and tested earlier in other empirical papers including Shockley and Turner (2015). We provide how effective inventory management may contribute to superior firm-level operational performance advantage for a given period. The hypotheses that we develop in this section are mainly inspired by the mathematical models of inventory theory.

We state the hypotheses examining the relationship of inventory efficiency to operating performance in U.S. fashion industries as:

Hypothesis 1. *A firm's relative inventory (XI) measure is negatively correlated with firm outperformance.*
Hypothesis 2. *A firm's gross margin return on inventory investment measure is positively correlated with firm outperformance.*
Hypothesis 3. *A firm's relative over-responsiveness (XC^+) or under-responsiveness (XC^-) is indicative of worse inventory management responsiveness and is negatively correlated with firm outperformance.*

$$rROA_{its} = b^1\ Independent\ variables_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{1}$$

$$rROS_{its} = b^1\ Independent\ variables_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{2}$$

We develop linear regression models Eqs. (1)–(6), where dependent variables $rROA_{its}$ and $rROS_{its}$ are the firm's segment-adjusted ROA and ROS performance. b^1 is the coefficient for each of the firm-specific indicator variables for inventory management performance; in other words, XI, GMROII, XC; b^2 and b^3 denote the coefficients for total individual firm capital investment (K_{it}) and change in firm sales from the prior year (ΔS_{it}), respectively; lastly b^4 and b^5 are the coefficients for the segment-adjusted firm-level control variables, gross margin (rGM_{it}) and segment-adjusted non-inventory fixed assets $(rSOA_{it})$ respectively; and ε_{it} is random model error.

Model 1 (efficiency)

$$rROA_{its} = b^1 XI_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{3}$$

$$rROS_{its} = b^1 XI_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{4}$$

Model 2 (productivity)

$$rROA_{its} = b^1 GMROII_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{5}$$

$$rROS_{its} = b^1 GMROII_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{6}$$

Model 3 (responsiveness)

$$rROA_{its} = b^1 XC_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{7}$$

$$rROS_{its} = b^1 XC_{it} + b^2 K_{it} + b^3 \Delta S_{it} + b^4 rGM_{it} + b^5 rSOA_{it} + \varepsilon_{it} \tag{8}$$

4 Results

Our study shows strong support for H1 and H2 as each inventory performance indicator is a statistically significant predictor of firm outperformance. The inventory efficiency relative inventory measure (XI) is significant ($p < 0.05$) and negatively correlated with operating performance. The inventory productivity measure, gross margin return on investment (GMROII) is significant ($p < 0.05$) and positively correlated with operating performance. These results are consistent when using rROA or rROS as a dependent variable. On the other hand, H3 is not supported, and is weak when using neither rROA nor rROS as a dependent variable. XC^+ does not indicate worse rROA or rROS performance. Overall, the results for inventory responsiveness suggests that fashion firms that over-corrected in their inventory relative to sales changes outperform competitors (Tables 7 and 8).

Table 7 Coefficient estimates for Models 1, 2 and 3 with relative ROA performance

	Model 1		Model 2		Model 3	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
XI	−0.285*	−4.86				
GMROII			2.974*	3.00		
XC^+					0.011	0.14
XC^-						
K	0.042*	2.61	0.094*	4.59	0.057*	3.39
ΔS	0.818*	9.33	0.837*	9.19	0.899*	9.87
rGM	0.306*	3.77	0.085	1.10	0.138	1.79
rSOA	0.021*	3.18	0.018*	2.69	0.016*	2.45
Constant	0.112*	2.19	−0.123*	−2.03	−0.006	−0.14
R^2	45.66%		42.31%		40.05%	
R^2 (adj)	44.47%		41.05%		38.73%	

*$p < 0.05$

Table 8 Coefficient estimates for models 1, 2 and 3 with relative ROS performance

	Model 1		Model 2		Model 3	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
XI	−0.092*	−3.47				
GMROII			0.608	1.36		
XC^+					0.043	1.14
XC^-						
K	0.030*	4.22	0.043	4.68*	0.037*	4.98
ΔS	0.337*	8.51	0.351	8.59*	0.368*	9.18
rGM	0.107*	2.91	0.041	1.20	0.053	1.56
rSOA	−0.005*	−1.99	−0.007	−2.31*	−0.007*	−2.31
Constant	0.018	0.78	−0.044	−1.61	−0.025	−1.18
R^2	45.02%		42.59%		42.44%	
R^2 (adj)	43.82%		41.33%		41.18%	

*$p < 0.05$

5 Discussion and Conclusion

In this paper, we have applied a model provided in Shockley and Turner (2015) to the U.S. fashion apparel and accessory industries in order to observe the relationship between inventory management and operational performance advantages. We have contributed to inventory management research by observing the impact of inventory management performance indicators over a 6-year period 2010–2015. Our result indicates that inventory efficiency and productivity significantly impact firm operating performance. In response to Hypothesis 1, it is found that firms that

operate a leaner and more efficient inventory system significantly outperform competitors. Similarly, in response to Hypothesis 2, firms having higher gross margin returns on inventory investment obtain superior operating performance.

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