SALES FORECAST INACCURACY AND INVENTORY TURNOVER PERFORMANCE: AN EMPIRICAL ANALYSIS OF U.S. RETAIL SECTOR

A THESIS

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MASTER OF SCIENCE

By

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July, 2010

I certify that I have read this thesis and that in my opinion it is full adequate, in scope and in quality, as a dissertation for the degree of Master of Science.

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ABSTRACT

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We develop an empirical model to investigate the impact of various financial measures on inventory turnover performance. In particular, we used inaccuracy of quarterly sales forecasts as a proxy for demand uncertainty and study its impact on firm level inventory turnover ratios. The model is implemented on a sample financial data for 304 publicly listed U.S. retail firms for the 25-year period 1985-2009. Controlling for the effects of retail sub-segments and year, it is found that inventory turnover is negatively correlated with mean absolute percentage error in sales forecast and gross margin, and positively correlated with capital intensity and sales surprise. In addition to providing managerial insights regarding the determinants of a major operational performance metric, our results can also be used to benchmark a retailer's inventory performance against its competitors.

Keywords: Inventory turnover, retail operations, sales forecast

ÖZET

A.B.D PERAKENDE SEKTÖRÜNDE SATIŞ TAHMİN HATASI VE ENVANTER DÖNÜŞ HIZI PERFORMANSININ AMPİRİK ANALİZİ

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Bu çalışmada, çeşitli finansal ölçütlerin envanter dönüş hızı performansı üzerindeki etkisini araştırmak için ampirik model geliştirilmiştir. Özellikle, talepteki belirsizliğini ifade etmek için çeyrek dönemlik satış tahminlerindeki hata kullanılıp, bunun envanter dönüş hızına olan etkisi araştırılmıştır. 1985-2009 yılları arasında Amerika Birleşik Devletleri'nde, halka açık, farklı sektörlerde yer alan 304 adet perakende şirketinin finansal bilgileri incelendi. Perakende sektörü ve zamanın etkisi kontrol edilerek, envanter dönüş hızının çeyrek dönemlik satış tahminlerindeki ortalama mutlak hata ve brüt kâr oranı ile negatif; sermaye büyüklüğü ve sürpriz satış terimiyle pozitif korelasyonu gözlenmiştir. Yönetimsel uygulamalara ışık tutmanın yanı sıra; sonuçlarımız firmalar arası envanter performansını karşılaştırmak üzere de kullanılabilir.

Anahtar Kelimeler: Envanter dönüş hızı, perakende operasyonları, satış tahmini

To my parents…

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

Inventories represent the stocks of raw materials, work-in process items and finished goods that are kept to meet customer orders. Higher demand uncertainty, product variety, and customer service levels put increased pressure on managers to increase inventories. On the other hand, since 1980s, many changes in industry appear which tend to reduce inventories such as improvements in information technology, adoption of just-in-time, outsourcing, etc. Thus, keeping right levels of inventory is crucial in order to meet customer commitments while minimizing cost.

Inventory turnover rate is the ratio of cost of goods sold to average inventory level. It measures the number of times inventory sold or replaced in a period. Inventory turnover ratio is perhaps the most widely used metric to measure a company's operational performance. Since inventory turnover ratio scales inventory to sales, it can be used for evaluating performance progress over time and comparing the inventory performance across the firms.

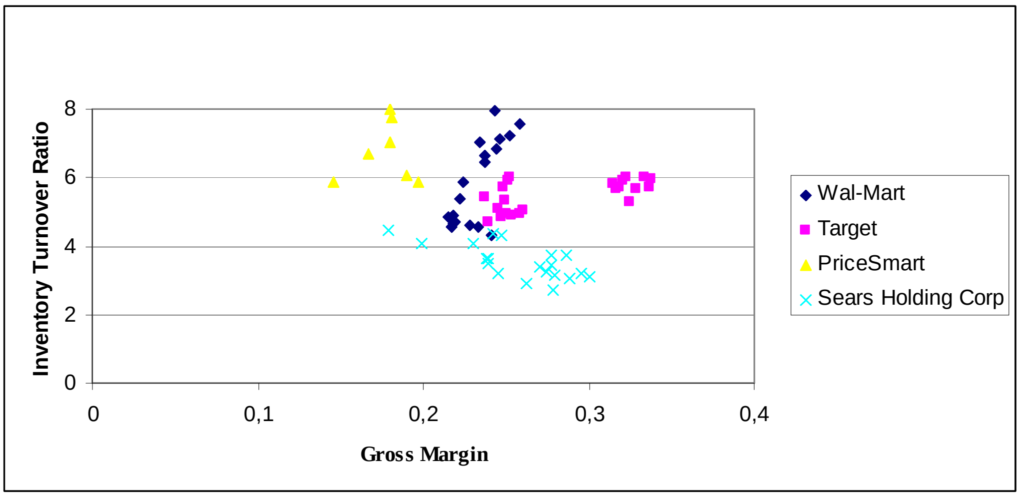
Usually a high turnover ratio indicates efficient management of inventory, i.e. goods are sold faster relative to the average amount of inventory kept in stock. On the other hand, a low turnover ratio indicates an inefficient management of inventory, i.e. goods are not moving rapidly (Silver et al., 1998). Inventory turnover ratio varies across industries and should only be used for benchmarking within an industry. For example, a fast-food restaurant would have a much higher inventory turnover rate than a company that sells jewelry because food is perishable, and obviously jewelry is not. Industry standards can be found for comparison purposes for almost every business.

In this study, our emphasis is the inventory performance of firms in retailing since major fraction of the assets of a retail firm is inventory. Thus, retailers pay great attention to the inventory productivity, and always try to improve their inventory management processes to reduce the inventory levels. Gaur et al.(2005) state that inventories represent, on average, 36% of the total assets and 53% of current assets in U.S. retail sector in 2003. Similarly our dataset illustrate that in 2009, on the average, inventory is the largest asset on the annual balance sheet for 57% of publicly traded retailers in our dataset. Inventory represents 23.5% of total assets and 58.3% of current assets for retailers.

In the beginning of 1990s, retailers start to try different strategies such as larger store formats, mergers and acquisitions, and apply new supply chain technologies. Owing to the development in the retail sectors, inventory turnover rate becomes an important indicator of their performance. Therefore, we'd like to observe the inventory turnover performance in retail sector. We use the financial data for all publicly listed U.S. retailers for the 25-year period 1985-2009, drawn from their quarterly and annual balance sheets and annual income statements. These data are obtained from Standard & Poor's Compustat database using the Wharton Research Data Services (WRDS).

It has been observed that the inventory turnover rate varies both across firms and within firms over time. For instance, during the 1985 – 2009 periods, the annual inventory turnover at Wal-Mart Stores Inc. (Wal-Mart), a variety retailer, ranged from 4.31 to 8.21. During the same period, the annual inventory turnover at three peer retailers of Wal-Mart shows similar variation such as, at Target Corporation from 4.69 to 6.02, at PriceSmart Inc., from 5.87 to 8.10, at Sears Holdings Corporation from 2.66 to 4.45. Figure 1 plots the annual inventory turnover ratio against gross margins of the four variety stores.

Figure 1: Annual inventory turnover ratio vs. annual gross margin for four retailers



Our starting point in this study is Gaur et al. (2005) who conduct a descriptive investigation of inventory turnover performance of publicly listed U.S. retailers for the time period 1985-2000. They find that this large fraction of the variation in inventory can be explained by three performance variables: gross margin (the ratio of gross profit net of markdowns to net sales), capital intensity (the ratio of average fixed assets to average total assets), and sales surprise (the ratio of actual sales to forecasted sales for the year).

The main contribution of this thesis is to introduce a fourth explanatory variable, inaccuracy of quarterly sales forecast, to explain the variation in inventory turnover ratio across firms, and segments of US retail industry and over the years. We use inaccuracy (and in particular mean absolute percentage error – MAPE) of quarterly sales forecasts as a proxy to quantify the demand variability that a firm faces when making inventory decisions and test the hypothesis that it as a significant impact on annual inventory turnover ratios in retail firms. We use Winter's triple exponential smoothing method and apply it individually by optimizing its three parameters to obtain the forecast for each firm. While forecast inaccuracy of quarterly sales of a firm may not be a direct indication of the amount of demand variability that it is exposed to its individual items due to aggregation, we use this measure in the absence of detailed demand data. This thesis also extends the study in Gaur et al. (2005) to a more recent and larger data set and tests to see whether the three hypotheses in Gaur et al. (2005) prevail with this data. In addition, we also comment on which retail firms operate successfully and which do not according to the differences between actual inventory turnover rates and inventory turnover rates that are predicted by the regression models that we develop.

The main results of this thesis are as follows. First, we show that mean absolute percentage error in quarterly sales forecast is negatively correlated with inventory turnover ratio in most of the retail segments. On the average, a 1% increase in MAPE is associated with a 0.01% decrease in inventory turnover. Second, we re-test the hypotheses in Gaur et al. (2005) regarding gross margin, capital intensity and sales surprise on our real world data set and find that inventory turnover is negatively correlated with gross margin, and positively correlated with capital intensity and sales surprise. On the average, in our data set, a 1% increase in gross margin is associated with a 0.34% decrease in inventory turnover (statistically significant at $p<0.00001$). Moreover, a 1% increase in capital intensity is associated with a 0.21% increase in inventory turnover, and a 1% increase in sales surprise is associated with a 0.10% increase in inventory turnover. These results are consistent with those obtained by Gaur et al. (2005). We believe that our study might be useful for retail managers to assess inventory turnover performance across firms and for a firm over time, and to benchmark it against the competing firms in industry.

The rest of this thesis is organized as follows. In Chapter 2, relevant literature is summarized. Chapter 3 describes the data set and defines the performance variables used throughout this thesis. In Chapter 4, our hypotheses to relate inventory turnover with gross margin, capital intensity, sales surprise and mean absolute percentage error in forecasts are presented. In Chapter 5, the empirical model is provided. Following that, in Chapter 6, we provide the numerical analysis. A general conclusion of the study is presented in Chapter 7.

Chapter 2

LITERATURE REVIEW

This chapter consists of a review of literature related to our study. The impacts of operational changes on financial and operational performance have been studied recently. Nevertheless, the numbers of empirical studies on these topics are scarce.

We begin with the study of Rajagopalan and Malhotra (2001) who study the trends in materials, work-in process and finished-goods inventory ratios for the 20 manufacturing industries for the period 1961 to 1964. They find that in a majority of industry sectors, raw material and work-in-process inventories decreased from 1961 to 1994. Yet, finished-goods inventories decreased in some industry sectors and increased in some others but did not show any overall trend. Authors show that total manufacturing inventory ratios improved at a higher rate during the pre-1980 period as compared with post-1980 period.

Hendricks and Singhal (2003) report that supply chain glitches, which resulted in production or shipment delays, decrease the shareholder value. Their results are based on a sample of 519 supply chain glitches that were publicly announced during 1989-2000. It is observed that larger firms' stock market reaction to supply chain glitches is less negative, and firms with higher growth prospects experience a more negative stock market reaction.

Hendricks and Singhal (2005) later examine the association between supply chain glitches and operating performance measures such as net sales, cost, inventory, etc. for the period of 1992-1999. Authors observe that these performance measures do not improve at least two years after the glitch announcement; hence firms do not recover quickly. It is determined that announcement of glitches are negatively correlated with net sales, inventory performance, profitability.

Similar to the study of Rajagopalan and Malhotra (2001), in an attempt to understand the trends in inventory levels for each of raw material inventory, work-in-process inventory and finished-good inventory, Chen at al. (2005) examine the inventories of publicly traded American manufacturing companies for the period 1981 to 2000. Authors observe the decline in raw material and work-in-process inventories; nevertheless, finished-goods inventory remained the same. As a result, majority of manufacturing firms in the United States reduced their inventories. In addition, the authors also find that firms with high inventories have poor long-term stock returns; firms with low inventories have unusually good long-term stock performance.

Chen et al. (2007) investigate whether the inventory turnover for U.S. retailers and wholesale firms have improved or not over the period from 1981 to 2004. They find that the average inventory that the firms carry decrease in manufacturing and wholesale firms, so wholesale firms increased their inventory turnover year by year. On the other hand, until 1995, inventory turnover ratios of retail firms remain stable. After 1995, retail firms started to improve the inventory turnover. Similar to Chen et al. (2005), it is stated that if the inventory performance of a company is poorer than the average, the firm has poor long-term stock market performance.

Boute et al. (2007) analyze differences in inventory turnover between manufacturing, wholesale and retail sectors. They only consider the year 2004, since their study aims to express cross-sectional differences. The data was extracted from Bel-First which contains statistics on Belgian and Luxembourg companies. They find that type of production process affects work-in process inventory. They further state that inventory turnover is significantly higher in retailer than wholesale.

Rumyantsev and Netessine (2007) analyze the panel data of a sample of 722 firms and find that better earnings are associated with responsive inventory management. They find that firms operating with demand uncertainty, longer lead times, and higher gross margins have larger inventories.

Aghazadeh (2009) presents the correlation between company's annual inventory turnover and its performance in retail industry. Using an empirical model, the author finds that future stock performance could be predicted by an indicator, which is the variance of annual inventory turnover of the firms. Various firms in different segments are analyzed in terms of their inventory turnover ratios. The author concludes that if managers are able to control inventory turnover, both stock performance and management quality of firms' are affected positively.

Our main motivation in this study is the paper by Gaur et al. (2005) who analyze the inventory turnover performance in the retail industry. They use financial data for 311 publicly listed retail firms for the period 1985-2000. The correlation of inventory turnover with gross margin, capital intensity and sales surprise are investigated. They develop several empirical models to test and strengthen their hypotheses. The basic results of their study are as follows: Inventory turnover is negatively correlated with the gross margin, positively correlated with the capital intensity with some exceptions, and positively correlated with the sales surprise. Time trends in inventory turnover and adjusted inventory turnover are computed as well. They find that inventory turnover in retailing industry declined from 1985-2000.

As an extension of the Gaur et al. (2005), Gaur and Kesavan (2007) observe the impact of firm size and sales growth rate on inventory turnover performance in retail industry. Authors find that inventory turnover is positively correlated with sales growth rate and growth rate is correlated with firm size. They use the 353 publicly listed retail firms for the period 1985-2003. Re-testing the hypotheses in Gaur et al. (2005) with larger and recent data set, they further obtain consistent results with Gaur et al. (2005), and demonstrate that inventory turnover is negatively correlated with gross margin, positively correlated with capital intensity, and positively correlated with sales surprise.

In most of these studies, the data typically used are obtained from the Standard & Poor's Compustat database, U.S. Census Bureau or LexisNexis.

Our main contribution in this study is to develop a metric to quantify the sales forecast inaccuracy that a firm faces and use this metric to understand the impact of demand variability on that firm's inventory turnover performance. In particular, we use Winter's triple exponential method to obtain forecasts, and mean absolute percentage error (MAPE) to quantify forecast inaccuracy. Our regression models are similar in sprit to Gaur et al. (2005): in addition to gross margin, capital intensity, and sales surprise, we include MAPE of quarterly sales forecasts as an explanatory variable and analyze its impact. Our data source is similar to Gaur et al. (2005), except that we include years 2001-2009 in our analysis. Our results show that in most of the sub-segments of US retail industry, MAPE is negatively correlated with inventory turnover ratio. In many sub-segments, introducing MAPE helps to explain more of the variability of inventory turnover ratio across firms and across years. We believe that our models can be effectively used to understand the impact of various factors on inventory performance and to benchmark a firm's inventory performance against its competitors in the marketplace.

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Chapter 3

DATA DESCRIPTION AND DEFINITION OF VARIABLES

We use the financial data for all publicly listed U.S. retailers for the 25-year period 1985-2009, which we drew from “Compustat North America – Quarterly Updates” and “Compustat North America – Annually Updated”. These data are obtained from Standard & Poor’s Compustat database using Wharton Research Data Services (WRDS).

A four-digit Standard Industry Classification (SIC) code is assigned to each firm according to its primary industry segment by the U.S. Department of Commerce. Our data set includes 10 segments in the retailing industry. 5 segments correspond to unique four-digit SIC codes. For example, the SIC code 5311 represents “Department Stores”, 5912 represents “Drug and Proprietary Stores”, 5944 represents “Jewelry Stores”, 5945 to “Hobby, Toy, and Game Shops”, and 5961 to “Catalog, Mail-Order Houses”. On the other hand, in the remaining 5 segments, similar to Gaur et al. (2005), we group together firms in similar product groups, as there are substantial overlaps among their products. For instance, all firms with SIC codes between 5600-5699 are collected in a segment called apparel and accessories. The SIC code 5600 represents the category “Apparel and Accessory Stores”, “5621 represents “Women’s Clothing Stores”, 5651 to “Family Clothing Stores”, and 5661 to “Shoe Stores”. Similarly, we group together supermarket chains and grocery stores, the SIC code 5400 represents “Food Stores”, 5411 to “Grocery Stores”, etc. This grouping enables to increase the number of degrees of freedom by estimating one set of coefficients for all apparel and accessory stores instead of estimating separate coefficients for each SIC codes. Table 1 lists all the segments, the corresponding SIC codes, and examples of firms in each segment.

Table 1: Classification of Retail Segments

Retail Industry Segment	**SIC Codes**	**Examples of firms**
Apparel and accessory stores	5600-5699	Claire’s Stores, Ann Taylor Stores, Abercrombie & Fitch, Foot Locker
Catalog, mail-order houses	5961	Amazon.com, Lands End, Sport Supply Group Inc., PC Connection Inc.
Department stores	5311	Belk, Macy's, Dillard's, Neiman Marcus, J.C. Penney
Drug and proprietary stores	5912	CVS, Rite Aid, Omnicare, Longs Drugs
Food stores	5400,5411	Albertson's, Kroger, Supervalu, Winn Dixie, Delhaize America
Hobby, toy, and game shops	5945	Toys R US, Electronics Boutique, Noodle Kidoodle
Home furniture and equip. Stores	5700,5712	Bed Bath & Beyond, Cost Plus, Haverty Furniture, Restoration Hardware
Jewelry stores	5944	Zale, Tiffany, Finlay Fine Jewelry, Signet Jewelers
Radio, TV, consumer electronics stores	5731,5734	Best Buy, Circuit City, Tweeter Home Entertainment Group, GameStop
Variety stores	5331,5399	99 Cents Only, Big Lots, Wal-Mart, Target, Costco

After observing the annual and quarterly data, which are available in “XML Excel Spreadsheet (xls)” format, we decided to organize the data in order to use them properly. At the beginning, the original data set contains 6561 annual and 25142 quarterly observations across 623 firms. There are several companies whose quarterly data is available but their annual data is missing and similarly there are several companies whose annual data is available but the quarterly data is missing.

Since our study needs both annul and quarterly data and we want to obtain realistic and sensible results, we eliminated the firms that have neither annual nor quarterly data set.

While organizing the quarterly data set, we follow several steps in Microsoft Visual Basic. Primarily, there are 4 fiscal quarters per year. In the quarter data, both the fiscal quarters and the corresponding fiscal years are available. Normally, it is expected that a fiscal year starts with fiscal quarter “1”, and it follows as “2”, “3” and ends with fiscal quarter “4”. However, there are some years that do not obey this rule. What we do is, check whether each firm’s available fiscal quarters of the years follow this rule or not. If not, delete the data corresponding to these years. Then, we exclude the firms that had missing data other than at the beginning or the end of their fiscal years. If the firms had missing data at the beginning or end of the measurement period, delete just the related years. The reason for these missing data might be bankruptcy filings, and subsequent emergence from bankruptcy. Further, for any sub-period during 1985-2003, we omit from our data set the firms that have less than seven consecutive years of data available for more accurate results. After completing the elimination process in the quarterly data, we revise the annual data accordingly. After organizing the data set as above, it is observed that the numbers of annual observations are 4236; quarterly observations are 16944 across 304 firms. Following this, we compute the performance variables. The computation of sales forecasts, using Holt’s and Winter’s Method, require at least two years of sales data at the beginning of each time series. Therefore, the first two years data could not be used in the analysis and we omit the first two years of data of each firm.

Our final data set contains 3628 annual, 14512 quarterly observations across 304 firms, and an average of 11.93 years of data per firm. Gaur et al. (2005) use financial data for publicly listed U.S. retailers for the 16-year period 1985-2000. Although our study consider the 25-year period 1985-2009, the number of firms that are observed are less in our case. Their final data set contains 3407 annual observations across 311 firms.

The notation of the data that we obtained from Compustat is used in calculations of performance variable, and is available in Table 2.

Table 2: Notation

S_{sit}	:	Sales, net of markdowns in dollars for firm i in segment s in year t (\$ million)
CGS_{sit}	:	Cost of goods sold in dollars for firm i segment s in year t (\$ million)
Inv_{sitq}	:	Inventory valued at cost for firm i segment s at the end of quarter q in year t (\$ million)
GFA_{sitq}	:	Gross fixed assets for firm i segment s at the end of quarter q in year t (\$ million)
A_{sitq}	:	Total assets for firm i segment s at the end of quarter q in year t (\$ million)
C_{sitq}	:	Current assets for firm i segment s at the end of quarter q in year t (\$ million)
$sales\_forecast_{sit}$	:	Annual sales forecast for firm i in segment s in year t (\$ million)
$sales\_forecast_{sitq}$	:	Quarterly sales forecast for firm i in segment s at the end of quarter q in year t (\$ million)

The performance variables are;

Inventory turnover rate is the ratio of cost of goods sold to average inventory levels.

$$IT_{sit} = \frac{CGS_{sit}}{\frac{1}{4}\sum_{q=1}^{4} Inv_{sitq}}$$

Gross margin is the ratio of gross profit net of markdowns to actual sales.

$$GM_{sit} = \frac{S_{sit} - CGS_{sit}}{S_{sit}}$$

Capital intensity is the ratio of average fixed assets to average total assets.

$$CI_{sit} = \frac{\sum_{q=1}^{4} GFA_{sitq}}{\sum_{q=1}^{4} Inv_{sitq} + \sum_{q=1}^{4} GFA_{sitq}}$$

Gross fixed assets, $GFA_{sitq} = A_{sitq} - C_{sitq}$

Sales surprise is the ratio of actual sales to expected sales for the year.

$$SS_{sit} = \frac{S_{sit}}{sales\_forecast_{sit}}$$

Mean Absolute Percentage Error (quarterly) is a measure of accuracy in a fitted timed series

$$MAPE_{sit\,q} = \frac{\left| S_{sitq} - sales\_forecast_{sitq} \right|}{S_{sitq}} \times 100$$

Mean Absolute Percentage Error (annual), $MAPE_{sit} = \frac{1}{4}\sum_{q=1}^{4} MAPE_{sitq}$

The annual sales forecasts are estimated using Holt's double exponential smoothing method which allows for simultaneous smoothing on the time series and the linear trend. The method requires the specification of smoothing constants α and β. It uses two smoothing equations: one for the value of the series (the intercept) and one for the trend (the slope) respectively. We use the formulations of Holt's method given by Nahmias (2005) with the notations that are provided below. Table 3 lists the definition of the parameters used in Holt's method.

Table 3: Notation for Holt's Method

G_{sit}	:	Value of the intercept for firm i in segment s in year t ($ million)
T_{sit}	:	Value of the slope for firm i in segment s in year t ($ million)
α	:	Smoothing constant for the intercept
β	:	Smoothing constant for the slope

$$G_{sit} = \alpha S_{sit} + (1-\alpha)(G_{si,t-1} + T_{si,t-1})$$

$T_{sit} = \beta(G_{sit} - G_{si,t-1}) + (1-\beta)T_{si,t-1}$, where α $(0 < \alpha < 1)$ and β $(0 < \beta < 1)$.

The 1-step-ahead forecast made in period t-1, which is denoted by $sales\_forecast_{sit}$ is given by

$$sales\_forecast_{sit} = G_{si,t-1} + T_{si,t-1}$$

Initialization Procedure for Holt's Method

In order to get the method started, we have to have initial estimates for the slope and the intercept.

$$sales\_forecast_{sit} = S_{sit}$$

$$G_{sit} = S_{sit}$$

$$T_{sit} = S_{si,t+1} - S_{sit}$$

The quarterly sales forecast are estimated using Winter's triple exponential smoothing method and has the advantage of being easy to update new data becomes available. The length of the season is N periods, and the method requires the specification of smoothing constants α , β and γ .

In our study, as there are 4 quarters in each year, the length of the season is 4 periods (N=4). We use the formulations of Winter's method given by Nahmias (2005) with the notations that are provided below. Table 4 lists the definition of the parameters used in Winter's method.

Table 4: Notation for the Winter's Method

E_{sitq}	:	Value of the series for firm i segment s at the end of quarter q in year t ($ million)
G_{sitq}	:	Value of the trend for firm i segment s at the end of quarter q in year t ($ million)
c_{sitq}	:	Value of the seasonal factors for firm i segment s at the end of quarter q in year t
S_{sitq}	:	Sales, net of markdowns in dollars for firm i segment s at the end of quarter q in year t ($ million)
V_{sit}	:	Value of the sample means for firm i segment s in year t ($ million)
α	:	Smoothing constant for the series
β	:	Smoothing constant for the trend
γ	:	Smoothing constant for the seasonal factors

1. *The series.* The current level of deseasonalized series, E_{sitq}, is given by

$$E_{sitq} = \alpha(S_{sitq} / c_{sit,q-N}) + (1-\alpha)(E_{sit,q-1} + G_{sit,q-1}), \text{ where } \alpha \ (0 < \alpha < 1)$$

2. *The trend.* It is updated in a fashion similar to Holt's method.

$$G_{sitq} = \beta[E_{sitq} - E_{sit,q-1}] + (1-\beta)G_{sit,q-1}, \text{ where } \beta \ (0 < \beta < 1)$$

3. *The seasonal factors.* The ratio of the most recent demand observation over the current estimate of deseasonalized demand gives the current estimate of the seasonal factor

$$c_{sitq} = \gamma(S_{sitq} / E_{sitq}) + (1-\gamma)c_{sit,q-N}, \text{ where } \gamma \ (0 < \gamma < 1)$$

4. *Sales forecast.* The forecast made in period q for any future period $q+\tau$ is given by

$sales\_forecast_{sitq} = F_{sit,q,q+\tau} = (E_{sit,q} + \tau G_{sit,q})c_{sit,q+\tau-N}$, where $q \le N$.

Initialization Procedure for Winter's Method

In order to get the method started, we need to obtain initial estimates for the series, the slope, and the seasonal factors. The method suggests that a minimum of two seasons of the data be available for initialization. Suppose that the current period is $q = 0$, so the past observations are labeled $S_{sit,-2N+1}, S_{sit,-2N+2}, \ldots, S_{sit0}$.

1. *Sample means for the two separate seasons of data*

$$V_{si1} = \frac{1}{N}\sum_{j=-2N+1}^{-N} S_{si1j}$$

$$V_{si2} = \frac{1}{N}\sum_{j=-N+1}^{0} S_{si2j}$$

2. *Initial slope estimate*

$$G_{sit0} = \frac{V_{si2} - V_{si1}}{N}$$

3. *Value of the series at time q=0*

$$E_{sit0} = V_{si2} + G_{sit0}\left[\frac{N-1}{2}\right]$$

4. a. Initial seasonal factors

$$c_{sitq} = \frac{S_{sitq}}{V_{sik} - \left[(N+1)/2 - j\right]G_{sit0}} \quad \text{for } -2N+1 \le q \le 0,$$

where $k=1$ for the first season(year), $k=2$ for the second season(year), and j is the period(quarter) of the season(year). That is, $j=1$ for $q=-2N+1$ and $q=-N+1$; $j=2$ for $q=-2N+2$ and $q=-N+2$, and so on.

b. Average seasonal forecasts assuming that exactly two seasons of initial data

$$c_{sit,-N+1}=\frac{c_{sit,-2N+1}+c_{sit,-N+1}}{2},\ldots,c_{sit0}=\frac{c_{sit,-N}+c_{sit0}}{2}$$

c. Normalize the seasonal factors

$$c_{sitj}=\left[\frac{c_{sitj}}{\sum_{k=0}^{-N+1}c_{sikj}}\right].N \quad \text{for } -N+1\le j\le 0$$

Here, using quarterly closing values, average inventory, average gross fixed assets, quarterly sales forecast are computed so as to control for systematic seasonal changes in these variables during the year. The method for obtaining the annual sales forecast and quarterly sales forecast will be described in Chapter 4.

Table 5 shows the descriptive statistics for each retailing segment for the performance variables by listing the mean, median and standard deviation. For the variety stores, for instance, the average inventory turnover rate for variety is 4.154, the standard deviation (stated in parenthesis) is 2.398 and the median inventory rate is 3.448. It is detected that food retailers have the lowest mean gross margin of 0.25 and the highest mean inventory turnover of 11.38. On the contrary, jewelry stores have the highest mean gross margin of 0.41 and the lowest mean inventory turns of 2.32.

Table 5: Summary statistics of the variables for each segment

Retail Industry Segment	**SIC codes**	**Number of firms**	**Number of annual observations**	**Average annual sales ($ million)**	**Average inventory turnover**	**Average gross margin**	**Average capital intensity**	**Average sales surprise**	**Average mean abs. perc. error**	**Median Inventory Turnover**	**Median Gross Margin**	**Median Capital Intensity**	**Median Sales Surprise**	**Median mean abs. perc. error**
Apparel and accessory stores	5600-5699	73	935	1,536.658	4.111 (1.691)	0.362 (0.099)	0.240 (0.116)	1.015 (0.282)	0.065 (0.06)	3.942	0.357	0.224	1.001	0.048
Catalog, mail-order houses	5961	39	380	830.261	8.741 (7.828)	0.360 (0.154)	0.288 (0.213)	1.077 (0.555)	0.128 (0.109)	5.612	0.371	0.225	0.225	0.07
Department stores	5311	21	289	4,775.720	3.222 (0.816)	0.334 (0.074)	0.268 (0.087)	1.058 (0.375)	0.055 (0.046)	3.141	0.348	0.275	1.005	0.037
Drug and proprietary stores	5912	23	267	6,593.223	9.574 (12.305)	0.261 (0.079)	0.286 (0.223)	1.21 (1.33)	0.074 (0.145)	5.367	0.275	0.223	1.017	0.04
Food stores	5400,5411	54	674	6,896.458	11.379 (4.487)	0.252 (0.078)	0.420 (0.128)	1.022 (0.201)	0.107 (1.349)	10.423	0.262	0.421	0.999	0.03
Hobby, toy, and game shops	5945	7	80	3,117.592	2.652 (0.905)	0.322 (0.096)	0.171 (0.103)	0.930 (0.555)	0.096 (0.16)	2.429	0.343	0.146	1.003	0.047
Home furniture and equip. stores	5700,5712	19	232	846.137	3.942 (5.132)	0.395 (0.085)	0.229 (0.132)	1.02 (0.16)	0.064 (0.05)	2.979	0.405	0.195	1.008	0.048
Jewelry stores	5944	14	163	691.170	2.323 (4.303)	0.411 (0.144)	0.125 (0.068)	1.027 (0.242)	0.121 (0.19)	1.340	0.470	0.110	0.999	0.072
Radio, TV, consumer electronics stores	5731,5734	17	201	3,586.531	3.776 (1.382)	0.317 (0.103)	0.155 (0.082)	1.028 (0.200)	0.079 (0.08)	3.659	0.289	0.139	1.014	0.054
Variety stores	5331,5399	37	407	14,669.962	4.154 (2.398)	0.285 (0.084)	0.196 (0.114)	1.013 (0.188)	0.056 (0.06)	3.448	0.279	0.171	1.008	0.039

Chapter 4

HYPOTHESIS DEVELOPMENT

In this chapter, we set up hypotheses to relate inventory turnover to gross margin, capital intensity, sales surprise and mean absolute percentage error in seasonal sales forecast using data for 304 publicly listed U.S. retailers for the period 1985-2009. Gaur et al. (2005) study the correlation of inventory turnover with gross margin, capital intensity and sales surprise for the period 1985-2000. In their paper, gross margin, capital intensity, and sales surprise are defined as shown in the previous chapter. In this study, we study the impact of quarterly sales forecast inaccuracy, as measured with mean absolute percentage error, on inventory turnover ratio.

4.1. Gross Margin

Hypothesis 1. *Inventory turnover is negatively correlated with gross margin.*

Gross margin is the proportion of gross profit net of markdowns (difference between actual sales and the production costs excluding taxation, interest payments, payroll) to actual sales. It represents the percentage of total sales revenue that the firm retains after incurring the direct costs. The higher the gross margin has, the more efficient company is. Retailers would be inclined to carry more inventory for products with higher gross margins as they would want to reduce or eliminate the number of stock-outs. Gaur et al. (2005) test this hypothesis using the data from period 1985-2009. Using larger and more recent data set, we would like to detect consistency and compare the current results to them.

4.1. Capital Intensity

Hypothesis 2. *Inventory turnover is positively correlated with capital intensity.*

Capital intensity specifies how much money is invested to produce one dollar of sales revenue. Therefore, retailers with high capital intensity mean investing more on information technology, machinery, management systems, etc. which increase their efficiency in operations. The companies can follow and meet the customers' demands easily and it is easy to increase their productivity and customer satisfaction which affects the inventory turnover positively. Again, this hypothesis is tested in Gaur et al. (2005) and we would like to retest it with a larger and more current dataset.

4.2. Sales Surprise

Hypothesis 3. *Inventory turnover is positively correlated with sales surprise.*

Sales surprise is ratio of actual sales to sales forecast. Sales surprise will increase if the demand is underestimated which means that actual sales are higher than the sales forecast. Since the actual sales are more in quantity, the average inventory level decreases which would lead to a one time increase in the inventory turnover ratio for that year. Alternatively, if the sales surprise is small, we would have a one time reduction increase in the inventory turnover for that year as there would be an inventory build-up.

We follow Gaur et al. (2005) and use Holt's method to calculate sales forecasts. In Holt's method, α and β values need to optimized for best forecast accuracy. The forecast errors for several values of α and β are compared by Gaur et al. (2005), and it is observed that $\alpha = 0.75$ and $\beta = 0.75$ give the best forecasts. Although we do not have completely same data set, we use the same smoothing constant values in our analysis.

4.3. Mean Absolute Percentage Error in Quarterly Sales Forecasts

Hypothesis 4. *Inventory turnover is negatively correlated with mean absolute percentage error in quarterly sales forecasts.*

This hypothesis is based on the belief that sales forecast inaccuracy should negatively impact the amount of inventory that retail firms carry. Theoretical models of inventory theory all suggest that increased demand variability lead to higher inventories. The main issue here is how one can measure demand variability in an empirical setting. One approach is to measure it directly using item level detailed demand data. However this is not possible since the demand data of retail firms is usually not publicly available and capturing and measuring variability over thousands of stock keeping units of hundreds of companies would not be possible computationally. Therefore, one needs to use a proxy to measure demand variability. We choose to use inaccuracy of sales forecasts as measured by mean absolute percentage of quarterly sales forecasts. Using inaccuracy of sales forecasts obtained by a standard forecasting technique is in line with how companies make inventory decisions in practice. Potentially, there could be two problems with using this particular proxy. First, due to aggregation of all stock keeping units for a company, variability in quarterly sales, and thus MAPE of quarterly sales forecasts is an approximate measure. Second, it assumes that sales correctly represent the original demand, while in fact there could be some censoring of data due to stock-outs. Nevertheless, in the absence of any other proxy that can be calculated with publicly available data sources, we believe that MAPE of quarterly sales forecasts should capture at least some of sales forecast inaccuracy that a firm faces.

Since quarterly sales forecast data includes seasonality, as stated in Chapter 3, we estimate sales forecasts from available data using Winter's triple exponential smoothing method. We compared the forecast errors for 125 different values of α, β and γ. All combinations of 0.1, 0.3, 0.5, 0.7, 0.9, for α, β and γ are observed ((0.1,0.1,0.1), (0.1,0.1,0.3), (0.1,0.1,0.5),…(0.9,0.9,0.9)) so that we have to run the macro code 125 times. In order to decide the best α, β and γ pair for our models, we try several approaches.

(i) Firstly, we would like to find the best weighting constants for each segment, and use these values in our forecast model accordingly. While doing this, we record the mean MAPE values of every segment for every α, β and γ triples, then select the α, β and γ pair that give the minimum overall mean MAPE for that segment. Thus, we use one only one set of α, β and γ values Table 6 shows the best α, β and γ values that provide the minimum overall mean MAPE values in each segment and seasonal factors.

Table 6: The best α, β and γ for each segment and seasonal factors

Retail Industry Segment	**SIC codes**	α	β	γ	c_1	c_2	c_3	c_4
Apparel and accessory stores	5600-5699	0.5	0.1	0.9	0.91	0.94	0.96	1.15
Catalog, mail-order houses	5961	0.3	0.5	0.7	0.94	0.93	0.95	1.16
Department stores	5311	0.7	0.1	0.9	0.88	0.91	0.94	1.26
Drug and proprietary stores	5912	0.7	0.1	0.5	1.00	0.97	0.97	1.05
Food stores	5400,5411	0.7	0.3	0.7	0.99	0.97	0.96	1.06
Hobby, toy, and game shops	5945	0.7	0.1	0.7	0.81	0.77	0.86	1.54
Home furniture and equip. stores	5700,5712	0.7	0.1	0.9	0.92	0.96	0.96	1.14
Jewelry stores	5944	0.5	0.1	0.9	0.87	0.92	0.95	1.15
Radio,TV,consumer electronics stores	5731,5734	0.5	0.3	0.5	0.93	0.96	0.95	1.06
Variety stores	5331,5399	0.5	0.3	0.7	0.85	0.92	0.88	1.32

(ii) Secondly, we try to find the best weighting constants for each firm where the MAPE values change year to year and firm to firm. Similar to previous one, now we record the mean MAPE values of every firm for every α, β and γ combination, then select the α, β and γ combination that give the minimum mean MAPE for that firm. Table 7 shows the best α, β and γ values of the some well-known retailers that provide the minimum mean MAPE values for these firms and the seasonal factors.

Table 7: The best α, β and γ for some of the firms and seasonal factors

SIC codes	**Company name**	α	β	γ	c_1	c_2	c_3	c_4
5311	MACY'S INC	0.9	0.1	0.9	0.90	0.84	0.94	1.30
5331	DOLLAR TREE INC	0.5	0.1	0.7	0.91	0.93	0.91	1.33
5331	TARGET CORP	0.5	0.1	0.7	0.91	0.94	0.97	1.32
5331	WAL-MART STORES INC	0.9	0.1	0.9	0.94	0.99	0.96	1.15
5399	COSTCO WHOLESALE CORP	0.5	0.3	0.9	0.94	1.01	0.89	1.24
5411	KROGER CO	0.3	0.1	0.9	1.08	0.91	1.05	0.96
5600	CLAIRES STORES INC	0.7	0.1	0.9	0.92	0.93	0.91	1.22
5621	ANNTAYLOR STORES CORP	0.7	0.1	0.5	0.98	1.00	0.96	1.05
5651	GAP INC	0.5	0.3	0.9	0.89	0.90	1.04	1.26
5700	BED BATH & BEYOND INC	0.3	0.7	0.5	0.91	0.97	1.03	1.09
5700	COST PLUS INC	0.5	0.3	0.9	0.83	0.81	0.82	1.52
5731	BEST BUY CO INC	0.5	0.3	0.9	0.90	0.95	1.06	1.14
5731	RADIOSHACK CORP	0.3	0.1	0.9	0.89	0.93	0.92	1.20
5912	CVS CAREMARK CORP	0.7	0.1	0.9	0.88	0.93	0.92	1.14
5912	RITE AID CORP	0.9	0.1	0.1	0.99	0.97	0.97	1.05
5944	TIFFANY & CO	0.5	0.1	0.9	0.84	0.90	0.89	1.35
5944	ZALE CORP	0.3	0.1	0.9	0.8	1.39	1.07	0.76
5945	NOODLE KIDOODLE INC	0.9	0.1	0.3	0.65	0.65	1.02	1.65
5945	TOYS R US INC	0.5	0.1	0.9	0.67	0.73	0.78	1.80
5961	AMAZON.COM INC	0.3	0.1	0.9	0.93	0.95	1.01	1.11
5961	LANDS END INC	0.5	0.1	0.5	0.82	0.76	0.95	1.45

After our observations, we decided to use α, β and γ values that are specific to each firm for our forecast models, as a firm would act independently and do its best to improve its forecasts.

One concern regarding Hypothesis 4 is that it may be closely related to Hypothesis 3, as one can perceive MAPE of quarterly sales forecasts and annual sales surprise to be very closely defined metrics. Our purpose for defining a new explanatory variable is as follows. We believe that sales surprise only captures the "after the fact", one time impact of forecast errors on inventory. If one year, a firm sold more than what it projected, its inventory would be less than what it would projected. Alternatively, if the firm sold less than what it projected, its inventory would be more than it would be projected. With MAPE of quarterly forecasts, we would like to measure the impact of demand variability on a firm's decisions. If a firm knows that it is exposed to high forecast inaccuracy (or high demand variability), it would stock more safety stock to maintain its service level (which is assumed to be high in retail). Alternatively, if the firm's forecasts are usually accurate, it would not plan for too much stock.

Despite these arguments, however, we still need to understand the correlation between these two metrics as both are based on actual and forecasted values of demand. Table 8 shows the correlation coefficients' estimates and the statistics for different segments. At 0.01 level, there is significant correlation between these two metrics only for the drug and propriety stores (positive correlation) and variety stores (negative correlation).

Table 8: Pearson Correlation of Sales Surprise and Mean Absolute Percentage Error

Retail Industry Segment	**SIC Codes**	**Estimate**	**P-value**
Apparel and accessory stores	**5600-5699**	-0,003	0,918
Catalog, mail-order houses	**5961**	0,086	0,095
Department stores	**5311**	0,1	0,09
Drug and proprietary stores	**5912**	0,161	0,008
Food stores	**5400,5411**	0,03	0,443
Hobby, toy, and game shops	**5945**	-0,273	0,015
Home furniture and equip. stores	**5700,5712**	-0,027	0,681
Jewelry stores	**5944**	-0,142	0,07
Radio,TV, consumer electronics stores	**5731,5734**	-0,077	0,277
Variety stores	**5331,5399**	-0,129	0,009

Chapter 5

EMPIRICAL MODEL

We propose 5 models to test our hypotheses so as to draw further insights and better estimation than in Gaur et al. (2005). In each of the 5 models, we use different sets of explanatory variables, different combination of parameters, like gross margin, GM_{sit}, capital intensity, CI_{sit}, sales surprise, SS_{sit}, and mean absolute percentage error, $MAPE_{sit}$. The results of these different combinations of parameters and models, are compared in Chapter 6.

Until we finalize our data set, we try several data sets to observe different scenarios. We estimate the sub models with values of (1) only mean absolute percentage error lagged by one year (2) gross margin, capital intensity, sales surprise and mean absolute percentage error lagged by one year, (3) mean absolute percentage error values obtained by the scenario (i) in Chapter 4, (4) mean absolute percentage error values obtained by the scenario (ii) in Chapter 4.

The final data set that we use is (4), in which mean absolute percentage error values are obtained by the scenario (ii) and are not lagged.

We now provide the regression models that we use in our study.

Models

We use different regression models to test our hypotheses and quantify the impact of the four factors discussed above on inventory turnover ratio. These models are summarized in Table 9.

Table 9: Models, Levels and Explanatory Variables

Model	Level	Explanatory Variables
Model 1.0	Segment	Firm, Year, MAPE
Model 1.1	Segment	Firm, Year, GM, CI
Model 1.2	Segment	Firm, Year, GM, CI, SS
Model 1.3	Segment	Firm, Year, GM, CI, MAPE
Model 1.4	Segment	Firm, Year, GM, CI, SS, MAPE
Model 2.0	Pooled	Firm, Year, MAPE
Model 2.1	Pooled	Firm, Year, GM, CI
Model 2.2	Pooled	Firm, Year, GM, CI, SS
Model 2.3	Pooled	Firm, Year, GM, CI, MAPE
Model 2.4	Pooled	Firm, Year, GM, CI, SS, MAPE
Model 3.0	Segment	Segment, Year, MAPE
Model 3.1	Segment	Segment,Year, GM, CI
Model 3.2	Segment	Segment, Year, GM, CI, SS
Model 3.3	Segment	Segment, Year, GM, CI, MAPE
Model 3.4	Segment	Segment, Year, GM, CI, SS, MAPE
Model 4.0	Pooled	Segment, Year, MAPE
Model 4.1	Pooled	Segment, Year, GM, CI
Model 4.2	Pooled	Segment, Year, GM, CI, SS
Model 4.3	Pooled	Segment, Year, GM, CI, MAPE

Model 4.4	Pooled	Segment, Year, GM, CI, SS, MAPE
Model 5.0	Pooled	Year, MAPE
Model 5.1	Pooled	Year, GM, CI
Model 5.2	Pooled	Year, GM, CI, SS
Model 5.3	Pooled	Year, GM, CI, MAPE
Model 5.4	Pooled	Year, GM, CI, SS, MAPE

Model 1 uses firm and time specific fixed effects because we desire to control the impacts of these to our regression model. For each segment, regression models are run separately as the coefficients of estimates depend on segments.

Model 2 again use firm and time specific fixed effects; however, regression analysis is not carried out separately for each segment and segment specific coefficient estimates are not used. Now, the coefficients of estimate of a variable, GM for instance, are same for all the segments. Consequently, the coefficient of estimation for GM, CI, SS, and MAPE do not depend on the segments.

Model 3 uses segment and time specific fixed effects, and similar to Model 1, segment specific coefficient estimates are used. With the help of this model, we can compare the significance of firm specific effects with segment specific effects.

Similar to Model 3, Model 4 uses segment and time specific fixed effects; nevertheless, segment specific coefficient estimates are not used, as Model 2. Pooled coefficients of the variables GM, CI, SS, and MAPE are used as a replacement for segmentwise coefficients. We test whether coefficients of the variables change across segments.

To control for the fixed effects, Model 5 includes just time specific fixed effects. Like Model 2 and Model 4, we do not carry out regression analysis separately for each segment; as a result, segment specific coefficient estimates are not used. The definition of the variables and the coefficients used in these 5 models are available in Table 10.

5.1. Model 1

In this model, we control the effects of time (year) and firms in each segment while estimating how GM, CI, SS, and MAPE influence a firm's IT. Hence, it is better to use c_t as a time-specific fixed effect, F_i as a firm-specific fixed effects.

We would like to observe the effects of sales surprise and mean absolute percentage error to our models; therefore, (1.1) includes neither sales surprise nor mean absolute percentage error. Equation (1.1) just examines GM's and CI's effects on IT. In the Models (1.2) and (1.3), SS and MAPE are put into models respectively to compare their effects. In Model (1.1), both SS and MAPE variables are considered together. The results of Models (1.1)-(1.2) and (1.1)-(1.3) are compared at first. Then, (1.2)-(1.4) and (1.3)-(1.4) are evaluated respectively in Chapter 6.

Not only in Models (1.1), (1.2), (1.3), (1.4) but also in the other Models (2.1), (2.2),…, (5.4), we expect that $b_s^1, b^1 \leq 0$ and $b_s^2, b^2 \geq 0$, $b_s^3, b^3 \geq 0$, $b_s^4, b^4 \leq 0$ owing to the hypotheses that we state in Chapter 4.

Table 10: Notation for the regression models

F_i	:	Time-invariant firm-specific fixed effect for firm i
F_s	:	Time-invariant segment-specific fixed effect for segment s
c_t	:	Year-specific fixed effect for year t
b_s^1	:	coefficient of $\ln GM_{sit}$ for segment s
b_s^2	:	coefficient of $\ln CI_{sit}$ for segment s
b_s^3	:	coefficient of $\ln SS_{sit}$ for segment s
b_s^4	:	coefficient of $\ln MAPE_{sit}$ for segment s
b^1	:	coefficient of $\ln GM_{sit}$
b^2	:	coefficient of $\ln CI_{sit}$

b^3	:	coefficient of $\ln SS_{sit}$
b^4	:	coefficient of $\ln MAPE_{sit}$
ε_{sit}	:	error term for segment s, firm i, year t

$$\ln IT_{sit} = F_i + c_t + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (1.0)$$

$$\ln IT_{sit} = F_i + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + \varepsilon_{sit} \quad (1.1)$$

$$\ln IT_{sit} = F_i + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^3 \ln SS_{sit} + \varepsilon_{sit} \quad (1.2)$$

$$\ln IT_{sit} = F_i + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (1.3)$$

$$\ln IT_{sit} = F_i + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^3 \ln SS_{sit} + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (1.4)$$

5.2. Model 2

Model 2 estimates the correlation between IT and GM, CI, SS, and MAPE. This model uses firm and time specific fixed effects F_i, c_t respectively; the only difference from Model 1 is that we do not use segment-specific coefficient estimate so they are same across segments. Therefore, instead of b_s^1, b_s^2, b_s^3, b_s^4, we include the coefficients b^1, b^2, b^3, b^4.

$$\ln IT_{sit} = F_i + c_t + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (2.0)$$

$$\ln IT_{sit} = F_i + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + \varepsilon_{sit} \quad (2.1)$$

$$\ln IT_{sit} = F_i + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + \varepsilon_{sit} \quad (2.2)$$

$$\ln IT_{sit} = F_i + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (2.3)$$

$$\ln IT_{sit} = F_i + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (2.4)$$

5.3. Model 3

Model 3 uses segment specific fixed effects F_s, time specific fixed effects c_t and segment specific coefficient estimates b_s^1, b_s^2, b_s^3, b_s^4.

$$\ln IT_{sit} = F_s + c_t + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (3.0)$$

$$\ln IT_{sit} = F_s + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + \varepsilon_{sit} \quad (3.1)$$

$$\ln IT_{sit} = F_s + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^3 \ln SS_{sit} + \varepsilon_{sit} \quad (3.2)$$

$$\ln IT_{sit} = F_s + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (3.3)$$

$$\ln IT_{sit} = F_s + c_t + b_s^1 \ln GM_{sit} + b_s^2 \ln CI_{sit} + b_s^3 \ln SS_{sit} + b_s^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (3.4)$$

5.4. Model 4

Model 4 uses segment specific fixed effects F_s, time specific fixed effects c_t and similar to Model 2, pooled coefficients estimates b^1, b^2, b^3, b^4.

$$\ln IT_{sit} = F_s + c_t + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \quad (4.0)$$

$$\ln IT_{sit} = F_s + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + \varepsilon_{sit} \quad (4.1)$$

$$\ln IT_{sit} = F_s + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + \varepsilon_{sit} \qquad (4.2)$$

$$\ln IT_{sit} = F_s + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \qquad (4.3)$$

$$\ln IT_{sit} = F_s + c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \qquad (4.4)$$

5.5 Model 5

Here, time specific fixed effects c_t, and pooled coefficients estimates b^1, b^2, b^3, b^4 (similar to Model 2 and 4) are considered.

$$\ln IT_{sit} = c_t + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \qquad (5.0)$$

$$\ln IT_{sit} = c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + \varepsilon_{sit} \qquad (5.1)$$

$$\ln IT_{sit} = c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + \varepsilon_{sit} \qquad (5.2)$$

$$\ln IT_{sit} = c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \qquad (5.3)$$

$$\ln IT_{sit} = c_t + b^1 \ln GM_{sit} + b^2 \ln CI_{sit} + b^3 \ln SS_{sit} + b^4 \ln MAPE_{sit} + \varepsilon_{sit} \qquad (5.4)$$

Chapter 6

NUMERICAL RESULTS

We begin with the analysis of correlation between merely inventory turnover rate and mean absolute percentage error. Before observing the different combinations of explanatory variables, we look at the effect of mean absolute percentage error on inventory turnover rate in each of the 5 models. Model 1.0, Model 2.0, Model 3.0, Model 4.0 and Model 5.0 are the sub-models that are used to test the hypotheses. Table 11 shows the coefficients' estimates and statistics of the sub-models that are mentioned above. It is observed that in most of the case, inventory turnover is negatively correlated with mean absolute percentage error in quarterly sales forecast.

The other 4 versions of Model 1 are denoted as Model 1.1, Model 1.2, Model 1.3, and Model 1.4. In Model 1.1, the effects of gross margin and capital intensity on inventory turnover ratio are observed. Table 12 shows the coefficients' estimates and statistics of the Model 1.1. It is realized that in all segments, the coefficients estimates of gross margin are negative, $b_s^1 \leq 0$. Except two segments, with SIC codes 5945 and 5731, 5734 "Hobby, toy, and game shops" and "Radio, TV, consumer

Table 11: Coefficients' Estimates for Model 1.0. Model 2.0. Model 3.0. Model 4.0. Model 5.0

Coefficients' Estimates for Model 1.0		**LN MAPE**	**LN MAPE**				
		Estimate	**std error**	**P-value(mape)**	**SS**	**R-sq**	**R-sq(adj)**
Apparel and accessory stores	**5600-5699**	-0,01698	0,00963	0,078	136,2254	86,00%	84,40%
Catalog, mail-order houses	**5961**	-0,00923	0,03105	0,766	179,1999	82,20%	79,50%
Department stores	**5311**	-0,030008	0,01456	0,04	12,755	72,10%	67,40%
Drug and proprietary stores	**5912**	-0,07944	0,0265	0,003	170,0663	91,50%	89,70%
Food stores	**5400,5411**	-0,01287	0,00945	0,174	80,0409	81,80%	79,50%
Hobby, toy, and game shops	**5945**	-0,0022	0,05322	0,967	5,44743	72,20%	56,90%
Home furniture and equip. Stores	**5700,5712**	-0,0699	0,03384	0,04	41,0634	75,00%	69,50%
Jewelry stores	**5944**	0,03344	0,03967	0,401	54,7851	82,30%	77,40%
Radio,TV, consumer electronics stores	**5731,5734**	-0,03077	0,01756	0,082	26,1679	87,10%	84,00%
Variety stores	**5331,5399**	-0,02892	0,00929	0,002	94,8335	95,70%	94,90%
Coefficients' Estimates for Model 2.0		-0,010497	0,05836	0,072	1688,85	91,30%	90,50%
Coefficients' Estimates for Model 3.0		**LN MAPE**	**LN MAPE**				
		Estimate	**std error**	**P-value(mape)**	**SS**	**R-sq**	**R-sq(adj)**
Apparel and accessory stores	**5600-5699**	-0,00411	0,01798	0,819	43,8507	27,7	25,7
Catalog, mail-order houses	**5961**	-0,02025	0,04966	0,684	12,16	5,6	0,3
Department stores	**5311**	-0,02487	0,01935	0,2	1,959	11,1	3,7
Drug and proprietary stores	**5912**	0,10913	0,04852	0,025	45,6136	22,5	15,6
Food stores	**5400,5411**	-0,02145	0,01605	0,182	3,7056	3,8	0,4
Hobby, toy, and game shops	**5945**	-0,02075	0,04464	0,644	1,7705	23,5	2,3
Home furniture and equip. Stores	**5700,5712**	-0,00255	0,04101	0,184	14,1033	25,8	17
Jewelry stores	**5944**	0,24508	0,06434	0	9,6291	14,5	1
Radio,TV, consumer electronics stores	**5731,5734**	-0,08124	0,03717	0,03	6,3392	21,1	10,8
Variety stores	**5331,5399**	-0,14107	0,02954	0	24,8234	25	20,3
Coefficients' Estimates for Model 4.0		-0,01141	0,01013	0,26	977,913	52,9	52,4
Coefficients' Estimates for Model 5.0		-0,07174	0,01375	0	30,9521	1,7	1

electronic stores" respectively, coefficients estimates of capital intensity are positive $b_s^2 \geq 0$.

These results support Hypotheses 1 and 2. A %1 increase in gross margin leads to decrease in gross margin in all segments; however, the amount of this decrease varies across segment.

Table 13 shows the results of Model 1.2, where the performance variable sales surprise is added to regression model. Again, we observe the negative correlation between gross margin and inventory turnover in all segments; positive correlation between capital intensity and inventory turnover; positive correlation between sales surprise and inventory turnover for eight of the ten segments. Comparing the Adjusted R-Square values of Models 1.1 and 1.2, we detect that for nine of the ten segments, these values increase, which is expected. The highest increase in Adjusted R-Square value (R-sq(adj)) is recognized in the "Hobby, toy, and game shops" segment. The reason for comparing these two sub models in terms of their Adjusted R-Square values is that it is generally considered to be an accurate goodness-of-fit measure.

We include the performance variable, mean absolute percentage error, instead of sales surprise in the Model 1.3. The coefficients' of the gross margin and capital intensity are consistent with the previous models. Moreover, segmentwise estimates of the coefficient of $\ln MAPE_{sit}$ supports the Hypothesis $4, b_s^3 \geq 0$, for seven of the ten segments. The detailed coefficients' estimates are available in Table 14. When we compare the R-sq(adj) values of (1.1) and (1.3), we observe that the values remain same in "Catalog-mail order houses" and "food stores" segments; slight decrease in "Jewelry stores" and "Home furniture and equipment stores". On the other hand, for six of the ten segments, increase in R-sq(adj) value is noticed. Once more, highest increase in R-sq(adj) is recognized in the "Hobby, toy, and game shops" segment.

Table 12: Coefficients' Estimates for Model 1.1

		LN GM		LN CI				
		estimate	**std error**	**estimate**	**std error**	**SS**	**R-sq%**	**R-sq(adj)%**
Apparel and accessory stores	**5600-5699**	-0,20528	0,01602	0,20667	0,02304	140,2705	89,3	88,1
Catalog, mail-order houses	**5961**	-0,28293	0,06665	0,20857	0,03606	183,6643	84,8	81,9
Department stores	**5311**	-0,27011	0,02914	0,321	0,04841	14,39314	81,4	78,1
Drug and proprietary stores	**5912**	-0,6268	0,07794	0,26376	0,0512	189,6263	93,7	92,4
Food stores	**5400,5411**	-0,20608	0,02004	0,27704	0,031916	83,9296	85,8	84
Hobby, toy, and game shops	**5945**	-0,15999	0,03945	-0,07531	0,07498	5,40457	87,1	79,5
Home furniture and equip. Stores	**5700,5712**	-0,39218	0,08281	0,55535	0,04745	44,207	84,8	81,4
Jewelry stores	**5944**	-0,83633	0,09034	0,29674	0,04745	61,2618	92	89,8
Radio,TV, consumer electronics stores	**5731,5734**	-0,1163	0,02965	-0,00215	0,0364	26,44343	88	85,1
Variety stores	**5331,5399**	-0,26765	0,0525	0,07201	0,01419	95,2399	96,1	95,4

Table 13: Coefficients' Estimates for Model 1.2

		LN GM		LN CI		LN SS					
		estimate	**Std error**	**Estimate**	**std error**	**Estimate**	**std error**	**P-value(ss)**	**SS**	**R-sq%**	**R-sq(adj)%**
Apparel and accessory stores	**5600-5699**	-0,20567	0,01599	0,21238	0,02324	0,04717	0,03101	0,129	140,3612	89,4	88,2
Catalog, mail-order houses	**5961**	-0,30123	0,06524	0,20241	0,03524	0,24086	0,06433	0	182,3702	85,5	82,6
Department stores	**5311**	-0,26816	0,02726	0,29597	0,04548	0,18776	0,03131	0	14,8157	83,8	80,9
Drug and proprietary stores	**5912**	-0,61416	0,07597	0,24625	0,05009	0,08935	0,02469	0	190,3411	94,1	92,8
Food stores	**5400,5411**	-0,20389	0,02001	0,26479	0,03239	0,08825	0,04173	0,035	84,0003	85,9	84,1
Hobby, toy, and game shops	**5945**	-0,16346	0,04033	-0,01638	0,07149	0,1475	0,1195	0,223	5,167	89,2	82,2
Home furniture and equip. stores	**5700,5712**	-0,41538	0,08835	0,55187	0,0477	-0,02247	0,09471	0,813	44,3701	85,1	81,7
Jewelry stores	**5944**	-0,8363	0,08991	0,29654	0,04723	0,11529	0,07746	0,139	61,3542	92,2	89,9
Radio,TV, consumer electronics stores	**5731,5734**	-0,11608	0,03028	-0,00214	0,03652	-0,00269	0,06878	0,969	26,4434	88	85
Variety stores	**5331,5399**	-0,27482	0,05208	0,07319	0,01406	0,10418	0,03808	0,007	95,3225	96,2	95,5

Table 14: Coefficients' Estimates for Model 1.3

		LN GM		LN CI		LN MAPE					
		estimate	std error	Estimate	std error	estimate	std error	P-value(mape)	SS	R-sq %	R-sq(adj)%
Apparel and accessory stores	**5600-5699**	-0,20786	0,01596	0,20759	0,02293	-0,02615	0,008423	0,002	140,462	89,50%	88,20%
Catalog, mail-order houses	**5961**	-0,28784	0,06681	0,21217	0,03622	-0,0305	0,02935	0,299	183,7759	84,90%	81,90%
Department stores	**5311**	-0,2629	0,02919	0,32956	0,0483	-0,024	0,0119	0,046	14,4462	81,70%	78,40%
Drug and proprietary stores	**5912**	-0,63724	0,07702	0,25996	0,05055	-0,05941	0,02256	0,009	190,0153	93,90%	92,60%
Food stores	**5400,5411**	-0,20762	0,02004	0,2745	0,03195	0,013515	0,00837	0,107	83,9901	85,80%	84,00%
Hobby, toy, and game shops	**5945**	-0,15187	0,03788	-0,07987	0,07173	0,08154	0,03451	0,022	5,488	88,40%	81,20%
Home furniture and equip. stores	**5700,5712**	-0,39126	0,08318	0,55365	0,04847	0,0044	0,02432	0,855	44,2084	84,80%	81,30%
Jewelry stores	**5944**	-0,8424	0,09242	0,29567	0,04773	-0,00925	0,02735	0,736	61,2666	92,00%	89,70%
Radio,TV, consumer electronics stores	**5731,5734**	-0,12515	0,02946	-0,00394	0,0359	-0,04009	0,01688	0,019	26,5664	88,40%	85,50%
Variety stores	**5331,5399**	-0,27676	0,05167	0,07237	0,01394	-0,03142	0,0087	0	95,3814	96,20%	95,60%

Table 15: Coefficients' Estimates for Model 1.4

		LN GM		LN CI		LN MAPE		LN SS						
		estimate	Std error	estimate	std error	estimate	std error	estimate	Std Error	P-value (mape)	P-value (ss)	SS	R-sq	R-sq(adj)
Apparel and accessory stores	**5600-5699**	-0,20822	0,01593	0,21318	0,02312	-0,025873	0,00841	0,04624	0,03085	0,002	0,134	140,5488	89,50%	88,30%
Catalog, mail-order houses	**5961**	-0,31012	0,06533	0,20742	0,0353	-0,04635	0,02953	0,23872	0,06419	0,117	0	182,6118	85,60%	82,70%
Department stores	**5311**	-0,2609	0,02727	0,30457	0,04531	-0,02418	0,0112	0,18795	0,03108	0,032	0	14,86974	84,10%	81,10%
Drug and proprietary stores	**5912**	-0,62488	0,07477	0,24127	0,04927	-0,06456	0,02192	0,09372	0,02432	0,004	0	190,7987	94,30%	93,10%
Food stores	**5400,5411**	-0,20542	0,02001	0,26233	0,03238	0,01339	0,00835	0,0878	0,4168	0,109	0,036	84,0927	85,90%	84,10%
Hobby, toy, and game shops	**5945**	-0,14677	0,03773	-0,02025	0,06614	0,0912	0,03081	0,1076	0,114	0,005	0,339	5,2686	91,00%	84,80%
Home furniture and equip. Stores	**5700,5712**	-0,41528	0,08873	0,55169	0,04867	0,00048	0,02434	-0,02238	0,09506	0,984	0,814	44,3701	85,10%	81,60%
Jewelry stores	**5944**	-0,83817	0,09207	0,29622	0,04752	-0,00285	0,02759	0,11399	0,07879	0,918	0,15	61,3546	92,20%	89,80%
Radio,TV, consumer electronics stores	**5731,5734**	-0,12342	0,03	-0,00389	0,036	-0,04079	0,01706	-0,02282	0,06831	0,018	0,739	26,5689	88,40%	85,40%
Variety stores	**5331,5399**	-0,28256	0,05135	0,07339	0,01385	-0,029467	0,00868	0,0924	0,03767	0,001	0,015	95,4458	96,30%	95,60%

In addition to gross margin and capital intensity, Model 1.4 includes the performance variables sales surprise and mean absolute percentage error. All the coefficients' estimates support the Hypotheses 1, 2, 3 and 4 where $b_s^1 \leq 0$ and $b_s^2 \geq 0$, $b_s^3 \geq 0$, $b_s^4 \leq 0$. Table 15 lists the detailed statistics of Model 1.4. Except "Home furniture and equipment stores" segment, all the R-sq(adj) values are both higher in Model 1.4 and Model 1.3 than Model 1.2. Greatest improvement in R-sq(adj) is recognized in the "Hobby, toy, and game shops" segment.

Instead of segment-specific coefficients, pooled coefficients are used in Model 2 to test the hypotheses. There are 4 other versions of this model in which we perform different combinations of the parameters, GM_{sit}, CI_{sit}, SS_{sit}, $MAPE_{sit}$ as Model 1. The overall fit of Models 2.1, 2.2, 2.3, and 2.4 are statistically significant. Table 16 shows the coefficients' estimates for Model 2.1. Here, as we state in the previous chapter, the coefficients of estimation do not vary segment to segment. The pooled coefficients for $\ln GM_{sit}$ is -0.26653, $\ln CI_{sit}$ is 0.23001, and strongly support Hypothesis 1 and Hypothesis 2 respectively.

Model 2.2 supports the Hypotheses 1, 2 and 3. We observe that Adjusted R-Square value in Model 2.2 is higher compared to Model 2.1. For eight of the ten segments, R-Sq(adj) value in Model 2.2 is greater than R-Sq(adj) values in Model 1.2. Table 17 shows the statistics for Model 2.2.

Model 2.3 supports the Hypotheses 1, 2 and 4. We observe that Adjusted R-Square value in Model 2.3 is same as Model 2.1. Furthermore, Model 2.3 is not as statistically significant as Model 2.2. Table 18 shows the statistics for Model 2.3.

The pooled coefficients for $\ln GM_{sit}$, $\ln CI_{sit}$, $\ln SS_{sit}$, $\ln MAPE_{sit}$ in Model 2.4 prove that all hypotheses are supported. Adjusted R-Square value in Model 2.4 is higher compared to Model 2.1, 2.2 and 2.3. Except two segments, "Drug and proprietary stores" and "Variety stores", R-Sq(adj) value in Model 2.4 is greater than R-Sq(adj) values in Model 1.4. The statistics for Model 2.4 are available in Table 19.

Table 16: Coefficients' Estimates for Model 2.1

LN GM		LN CI				
estimate	Std error	Estimate	Std error	SS	R-sq%	R-sq(adj)%
-0,26653	0,0119	0,23001	0,01088	1718,866	93,2	92,6

Table 17: Coefficients' Estimates for Model 2.2

LN GM		LN CI		LN SS					
estimate	Std error	Estimate	Std error	Estimate	std error	P-value(ss)	SS	R-sq%	R-sq(adj)%
-0,26664	0,0118	0,22818	0,01079	0,10845	0,01353	0	1714,802	93,4	92,7

Table 18: Coefficients' Estimates for Model 2.3

LN GM		LN CI		LN MAPE					
Estimate	std error	estimate	Std error	Estimate	std error	P-value(mape)	SS	R-sq %	R-sq(adj)%
-0,26732	0,1678	0,23115	0,01087	-0,01593	0,00516	0,002	1719,226	93,30%	92,60%

Table 19: Coefficients' Estimates for Model 2.4

LN GM		LN CI		LN MAPE		LN SS						
Estimate	std error	Estimate	Std error	Estimate	std error	estimate	std error	P-value (mape)	P-value (ss)	SS	R-sq	R-sq (adj)
-0,2675	0,01179	0,2293	0,01078	-0,01666	0,00511	0,10786	0,01351	0,001	0	1715,193	93,40%	92,80%

To compare the significance of firm-specific fixed effects with segmentwise fixed effect, Model 3 is developed. Similar to the first two models, there are 4 other versions of Model 3. This model is functional and provides better estimation than Model 1, since it contains fewer parameters. Tables 20, 21, 22 and 23 show the statistics for Models 3.1, 3.2, 3.3 and 3.4 respectively. All the hypotheses stated in Chapter 4 are supported significantly by these models.

From Model 3.1, it is realized that in all segments, the coefficients estimates of gross margin are negative, $b_s^1 \leq 0$ and coefficients estimates of capital intensity are positive $b_s^2 \geq 0$, which are similar results with Model 1.1. One primary difference between two Models is that 3.1 gives more precise estimation, hence segment-specific fixed effects are statistically significant.

For Model 3.2, the segmentwise estimates of the coefficient of $\ln GM_{sit}$, $\ln CI_{sit}$, $\ln SS_{sit}$ support Hypotheses 1, 2 and 3. R-Sq(adj) values in Model 3.2 is greater than R-Sq(adj) values in Model 3.1. After comparing Models 3.2 and 3.1, we detect that greatest improvements in R-sq(adj) are recognized in the "Department stores" segments.

The R-Sq(adj) values in Model 3.3 is better than both in Model 3.1 and 3.2 so we can state that mean absolute percentage error is a better determinant of inventory turnover ratio than sales surprise. Comparing Models 3.3 and 3.1, we detect that greatest improvements in R-sq(adj) are recognized in the "Home furniture and equipment stores" segments.

The Model 3.4 includes all the performance variables in a single model. Majority of coefficients' estimates support the Hypotheses 1, 2, 3 and 4 where $b_s^1 \leq 0$ and $b_s^2 \geq 0$, $b_s^3 \geq 0$, $b_s^4 \leq 0$.

Table 20: Coefficients' Estimates for Model 3.1

		LN GM		LN CI				
		estimate	**std error**	**estimate**	**std error**	**SS**	**R-sq%**	**R-sq(adj)%**
Apparel and accessory stores	**5600-5699**	-0,33828	0,02418	0,42252	0,02057	85,0174	54,1	52,8
Catalog, mail-order houses	**5961**	-0,92767	0,04897	0,38078	0,03106	122,5417	56,6	53,8
Department stores	**5311**	-0,23953	0,03547	0,21942	0,0303	6,67982	37,8	32,4
Drug and proprietary stores	**5912**	-0,97683	0,07499	0,52488	0,04081	152,712	75,5	73,1
Food stores	**5400,5411**	-0,27067	0,02856	0,44865	0,03961	24,6429	25,2	22,4
Hobby, toy, and game shops	**5945**	-0,29864	0,0557	0,1332	0,04323	3,09766	49,9	29
Home furniture and equip. Stores	**5700,5712**	-0,7058	0,1195	0,46785	0,05934	18,6956	35,9	28
Jewelry stores	**5944**	-1,02336	0,05794	0,41576	0,05531	51,5386	77,4	73,7
Radio,TV, consumer electronics stores	**5731,5734**	-0,38833	0,04928	0,17543	0,05185	12,79006	42,5	34,7
Variety stores	**5331,5399**	-1,02621	0,03806	0,27281	0,01795	80,8728	81,6	80,4

Table 21: Coefficients' Estimates for Model 3.2

		LN GM		LN CI		LN SS					
		Estimate	**Std error**	**estimate**	**std error**	**estimate**	**std error**	**P-value(ss)**	**SS**	**R-sq%**	**R-sq (adj)%**
Apparel and accessory stores	**5600-5699**	-0,33824	0,02409	0,42688	0,02056	0,02782	0,05991	0,129	85,7215	54,6	53,2
Catalog, mail-order houses	**5961**	-0,93809	0,04781	0,37393	0,03041	0,30622	0,09501	0,001	124,8305	58,5	55,7
Department stores	**5311**	-0,23243	0,03497	0,21911	0,02981	0,17551	0,05614	0	7,07261	40	34,5
Drug and proprietary stores	**5912**	-0,96325	0,07401	0,51845	0,04026	0,13012	0,04467	0	154,3935	76,3	73,9
Food stores	**5400,5411**	-0,27152	0,02857	0,45204	0,03975	-0,08945	0,08809	0,035	24,7592	25,3	22,4
Hobby, toy, and game shops	**5945**	-0,31607	0,05569	0,13213	0,04224	0,3642	0,2142	0,095	3,00693	51,9	29,7
Home furniture and equip. Stores	**5700,5712**	-0,7546	0,1251	0,48378	0,06048	0,2405	0,1815	0,813	19,0796	36,6	28,5
Jewelry stores	**5944**	-1,01705	0,05763	0,40603	0,05518	0,214	0,1224	0,139	51,8642	77,9	74,1
Radio,TV, consumer electronics stores	**5731,5734**	-0,39553	0,04932	0,1745	0,05166	0,2081	0,1361	0,969	13,01774	43,3	35,2
Variety stores	**5331,5399**	-1,02428	0,03785	0,27236	0,01785	0,1759	0,07504	0,007	81,1336	81,9	80,6

Table 22: Coefficients' Estimates for Model 3.3

		LN GM		LN CI		LN MAPE					
		Estimate	**std error**	**estimate**	**std error**	**estimate**	**std error**	**P-value (mape)**	**SS**	**R-sq %**	**R-sq(adj)%**
Apparel and accessory stores	**5600-5699**	-0,33897	0,0243	0,42228	0,0206	-0,00441	0,01448	0,761	85,0248	54,1	52,8
Catalog, mail-order houses	**5961**	-0,93293	0,04886	0,38356	0,03099	-0,06154	0,03368	0,068	123,4174	57	54,1
Department stores	**5311**	-0,25059	0,0355	0,22104	0,02995	-0,0435	0,01615	0,008	6,97406	39,4	33,9
Drug and proprietary stores	**5912**	-1,0176	0,0712	0,50474	0,03849	-0,03427	0,0262	0,192	145.7241	78,4	76,2
Food stores	**5400,5411**	-0,27221	0,02848	0,45275	0,03954	-0,03099	0,01414	0,029	25,1816	25,7	22,9
Hobby, toy, and game shops	**5945**	-0,26558	0,05848	0,15718	0,04504	0,06703	0,04098	0,108	3,24434	52,3	31,1
Home furniture and equip. Stores	**5700,5712**	-0,7472	0,1157	0,51913	0,05624	0,20172	0,03404	0	25,3301	49,1	42,4
Jewelry stores	**5944**	-0,99389	0,06523	0,42961	0,05708	0,03707	0,03768	0,327	51,6433	77,6	73,7
Radio,TV, consumer electronics stores	**5731,5734**	-0,39602	0,0481	0,18366	0,05061	-0,09929	0,03108	0,002	13,7415	45,7	38
Variety stores	**5331,5399**	-1,0106	0,03773	0,26655	0,01776	-0,05262	0,01468	0	81,4711	82,2	81

Table 23: Coefficients' Estimates for Model 3.4

		LN GM	LN GM	LN CI	LN CI	LN MAPE	LN MAPE	LN SS	LN SS					
		estimate	**Std error**	**estimate**	**std error**	**estimate**	**std error**	**estimate**	**std error**	**P-value (mape)**	**P-value (ss)**	**SS**	**R-sq%**	**R-sq(adj)%**
Apparel and accessory stores	**5600-5699**	-0,33917	0,02421	0,42658	0,02058	-0,0059	0,01443	0,02813	0,05994	0,683	0,639	85,7347	54,6	53,2
Catalog, mail-order houses	**5961**	-0,94879	0,04725	0,37667	0,02999	-0,11315	0,03405	0,33818	0,09417	0,001	0	127,5251	59,8	56,9
Department stores	**5311**	-0,24435	0,0346	0,22095	0,02932	-0,05019	0,01593	0,19637	0,05561	0,002	0	7,45877	42,2	36,7
Drug and proprietary stores	**5912**	-1,01193	0,07171	0,50523	0,03854	-0,03766	0,02666	0,05463	0,07655	0,159	0,476	145,8107	78,4	76,3
Food stores	**5400,5411**	-0,273	0,0285	0,45591	0,03967	-0,03063	0,01414	-0,08443	0,08787	0,031	0,337	25,2852	25,8	22,9
Hobby, toy, and game shops	**5945**	-0,25369	0,06017	0,17253	0,04434	0,10328	0,04536	0,2269	0,2147	0,027	0,296	3,26368	56,4	35
Home furniture and equip. Stores	**5700,5712**	-0,7739	0,1178	0,52463	0,05639	0,19853	0,03412	0,2411	0,2067	0	0,245	25,5085	49,4	42,6
Jewelry stores	**5944**	-0,97911	0,06508	0,42261	0,05666	0,04693	0,03768	0,2351	0,1234	0,215	0,059	52,0288	78,2	74,2
Radio, TV, consumer electronics stores	**5731,5734**	-0,40108	0,04825	0,18258	0,05056	-0,09466	0,0313	0,1567	0,1341	0,003	0,244	13,8686	46,1	38,1
Variety stores	**5331,5399**	-1,01002	0,03759	0,26658	0,0177	-0,04918	0,01473	0,14626	0,07458	0,001	0,051	81,6488	82,4	81,1

Model 4 uses segment specific fixed effects F_s, time specific fixed effects c_t and pooled coefficients estimates b^1, b^2, b^3, b^4. In all the Models, the pooled coefficients for $\ln GM_{sit}$ are less than zero, and strongly supports Hypothesis 1. Hypothesis 2 is supported by the pooled coefficients for $\ln CI_{sit}$ that are nonnegative.

From the Models 4.2 and 4.4, we show that sales surprise is positively correlated with inventory turnover. Negative correlation between mean absolute percentage error and inventory turnover is detected from the Models 4.3 and 4.4. For each sub-model of Model 4, detailed coefficient estimates, p-values and R-sq(adj) values are shown in the Table 24, 25, 26 and 27.

Model 5 includes just time specific fixed effects c_t and pooled coefficients estimates b^1, b^2, b^3, b^4. The pooled coefficients for $\ln GM_{sit}$ varies from -0.72463 to -0.72584; $\ln CI_{sit}$ varies from 0.58227 to 0.58848; $\ln SS_{sit}$ varies from 0.16357 to 0.16718; and $\ln MAPE_{sit}$ varies from -0.01701 to -0.0215 across Models. As a result, all the hypotheses are supported by Model 5 as well. For each sub-model of Model 5, detailed coefficient estimates, p-values and R-sq(adj) values are shown in the Table 28, 29, 30 and 31.

Table 24: Coefficients' Estimates for Model 4.1

LN GM		LN CI				
Estimate	std error	estimate	std error	SS	R-sq%	R-sq(adj)%
-0,57172	0,0145	0,404	0,01111	1352,033	73,3	73,1

Table 25: Coefficients' Estimates for Model 4.2

LN GM		LN CI		LN SS					
Estimate	std error	estimate	std error	estimate	std error	P-value(ss)	SS	R-sq%	R-sq(adj)%
-0,57105	0,0144	0,4003	0,01107	0,15923	0,02479	0	1352,951	73,7	73,4

Table 26: Coefficients' Estimates for Model 4.3

LN GM		LN CI		LN MAPE					
Estimate	std error	estimate	Std error	estimate	std error	P-value (mape)	SS	R-sq %	R-sq(adj)%
-0,57367	0,01454	0,40402	0,01111	-0,01268	0,007671	0,099	1352,408	73,4	73,1

Table 27: Coefficients' Estimates for Model 4.4

LN GM		LN CI		LN MAPE		LN SS						
Estimate	Std error	Estimate	Std error	estimate	Std error	estimate	std error	P-value (mape)	P-value (ss)	SS	R-sq%	R-sq(adj)%
-0,57373	0,01445	0,40013	0,01106	-0,01696	0,007672	0,16173	0,02481	0,027	0	1353,611	73,7	73,4

Table 28: Coefficients' Estimates for Model 5.1

LN GM		LN CI				
estimate	std error	estimate	Std error	SS	R-sq%	R-sq(adj)%
-0,72582	0,01705	0,58848	0,01183	1046,44	56,8	56,5

Table 29: Coefficients' Estimates for Sub Model 5.2

LN GM		LN CI		LN SS					
estimate	std error	Estimate	Std error	estimate	std error	P-value(ss)	SS	R-sq%	R-sq(adj)%
-0,72463	0,01697	0,58561	0,01179	0,16357	0,03137	0	1050,081	57,2	56,9

Table 30: Coefficients' Estimates for Model 5.3

LN GM		LN CI		LN MAPE					
estimate	std error	estimate	Std error	estimate	std error	P-value(mape)	SS	R-sq %	R-sq(adj)%
-0,72584	0,01704	0,58598	0,01191	-0,01702	0,009203	0,065	1047,197	56,8	56,5

Table 31: Coefficients' Estimates for Model 5.4

LN GM		LN CI		LN MAPE		LN SS						
estimate	std error	estimate	Std error	estimate	std error	Estimate	std error	P-value (mape)	P-value (ss)	SS	R-sq%	R-sq(adj)%
-0,72548	0,01696	0,58227	0,01187	-0,02155	0,009229	0,16718	0,03139	0,02	0	1051,274	57,3	57

After finding the coefficients of estimations for each sub problem, we decide to calculate $\ln \tilde{IT}_{sit}$ to observe the variation from $\ln IT_{sit}$. The firm, whose $\ln IT_{sit} - \ln \tilde{IT}_{sit}$ value is above zero, is considered to perform better than the others. Conversely, if $\ln IT_{sit} - \ln \tilde{IT}_{sit}$ value is below zero, the inventory performance of the firm is below the benchmark.

In order to calculate $\ln \tilde{IT}_{sit}$, we use the coefficient estimates of Model 3.4, i.e.,

$$\ln \tilde{IT}_{sit} = F_s + c_t + \tilde{b}_s^1 \ln GM_{sit} + \tilde{b}_s^2 \ln CI_{sit} + \tilde{b}_s^3 \ln SS_{sit} + \tilde{b}_s^4 \ln MAPE_{sit} \qquad (3.4)$$

After we calculate $\ln IT_{sit} - \ln \tilde{IT}_{sit}$ values for each firm in ten segments, we observe the distribution of these values by years for all segments, and illustrate them in Figure 2 through 11. We further present some well-known retailers' status to give insight into how well they are operating their inventory systems. It is observed that the highest $\ln IT_{sit} - \ln \tilde{IT}_{sit}$ value is in "Catalog, mail-order houses" segment; the lowest value is in "Home furniture and equipment stores" segment.

Figure 2: Illustration of apparel and accessory stores

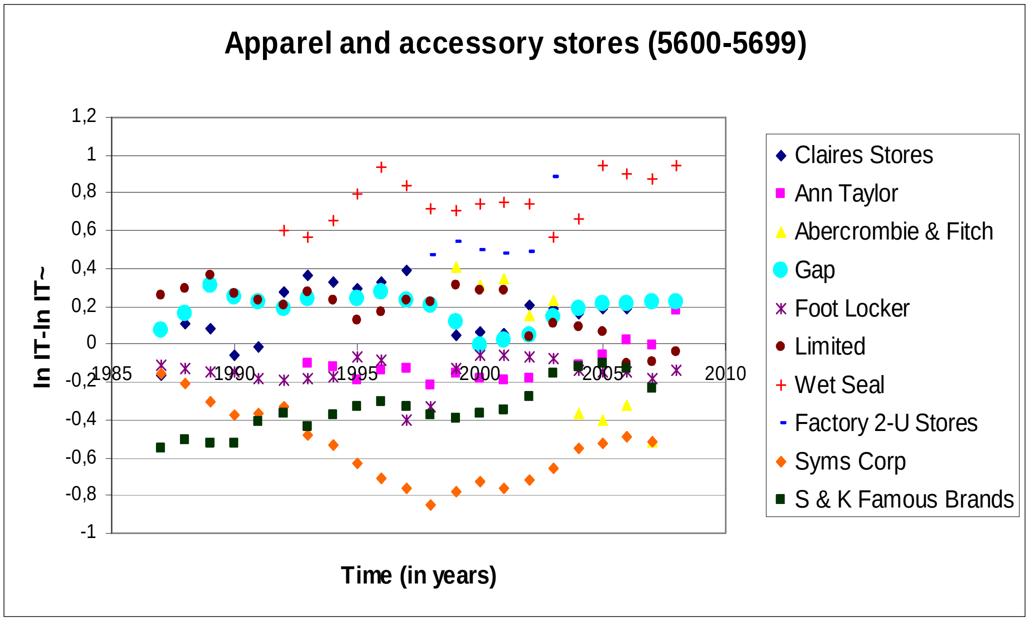


Figure 3: Illustration of catalog, mail-order houses

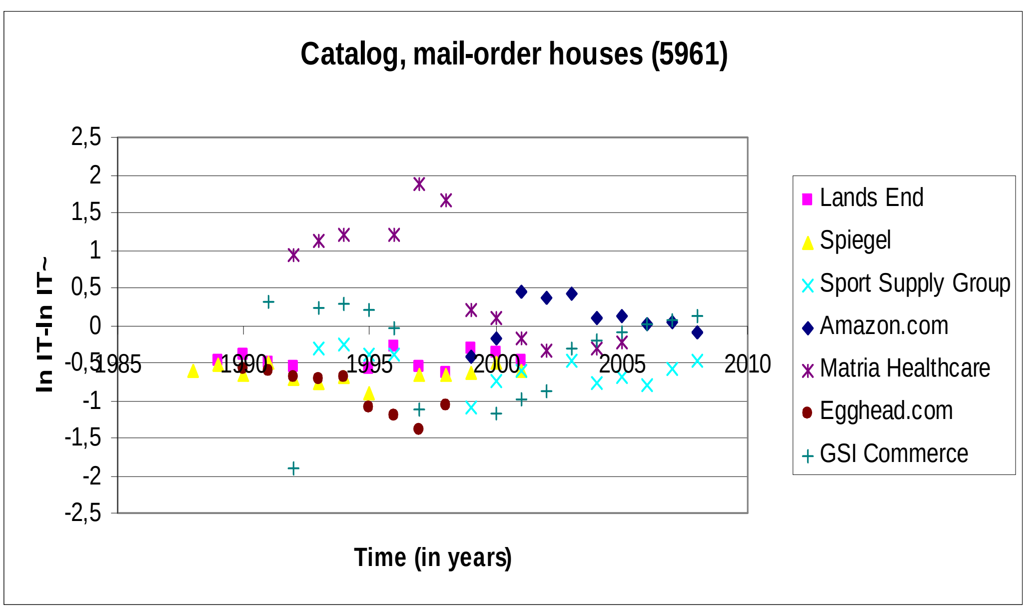


Figure 4: Illustration of department stores

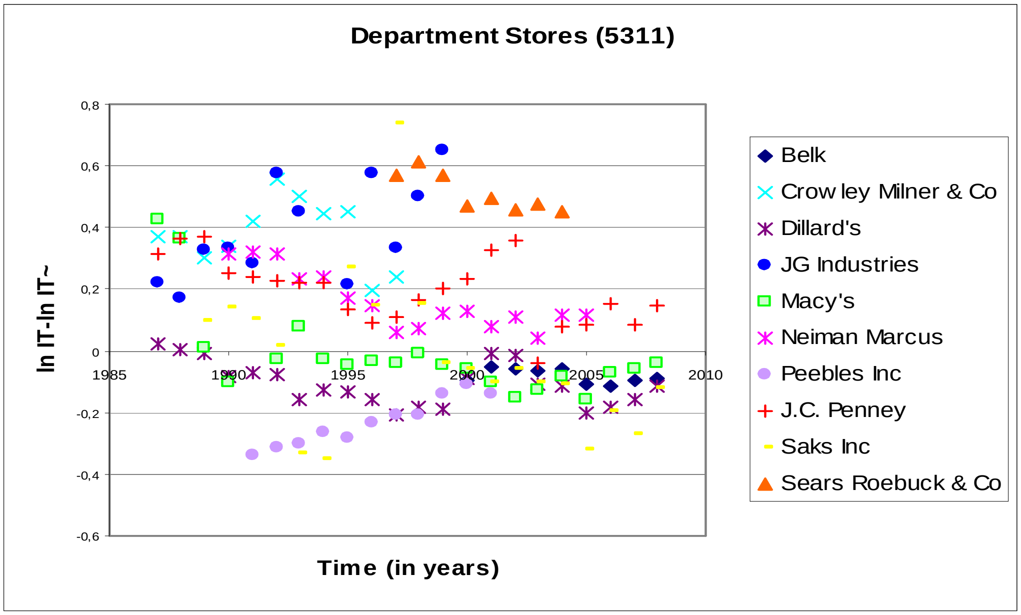


Figure 5: Illustration of drug and proprietary stores

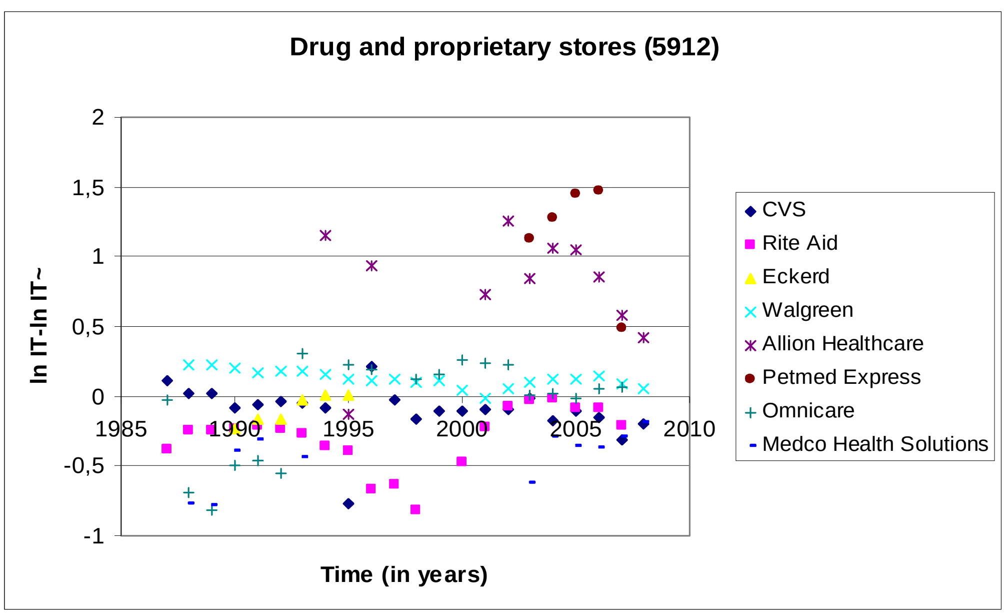


Figure 6: Illustration of food stores

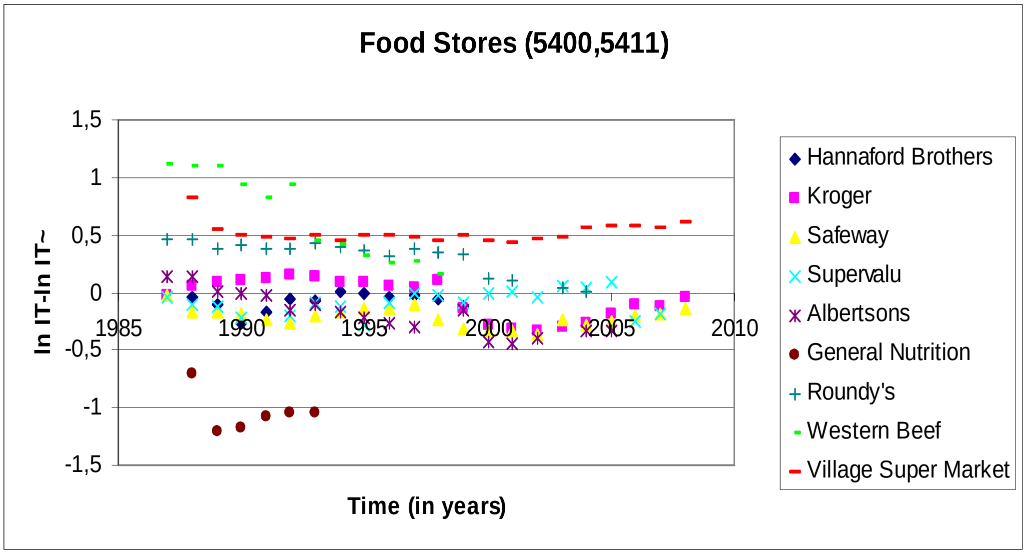


Figure 7: Illustration of hobby, toy, and game shops

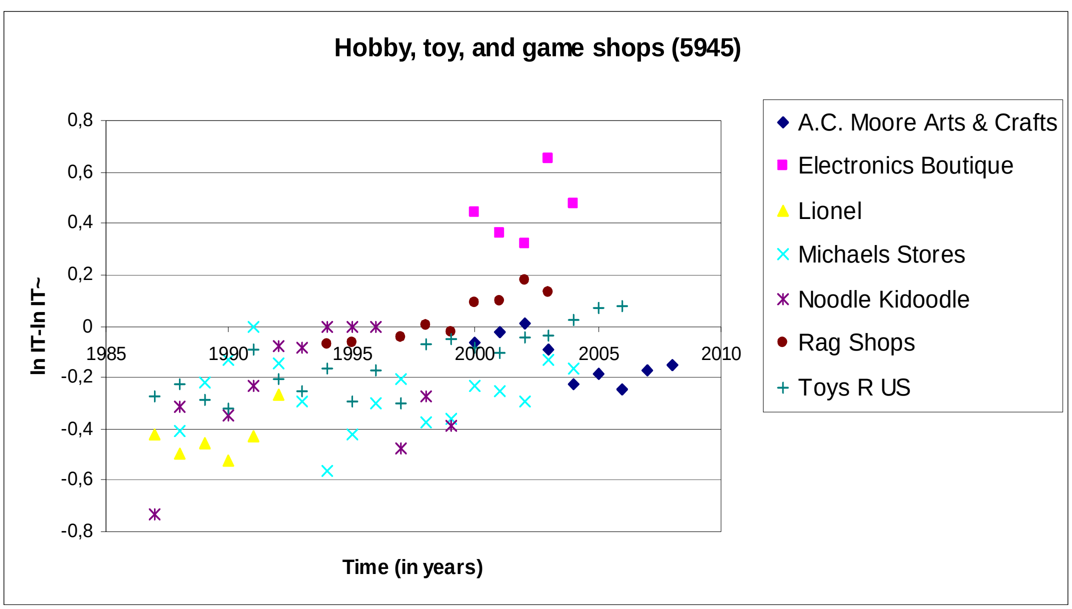


Figure 8: Illustration of home furniture and equipment stores

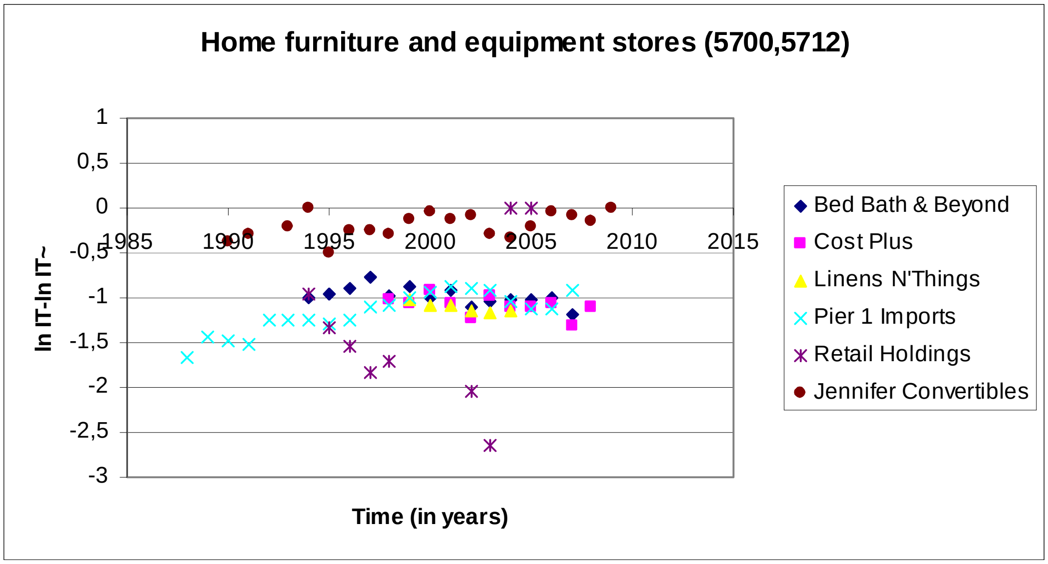


Figure 9: Illustration of jewelry stores

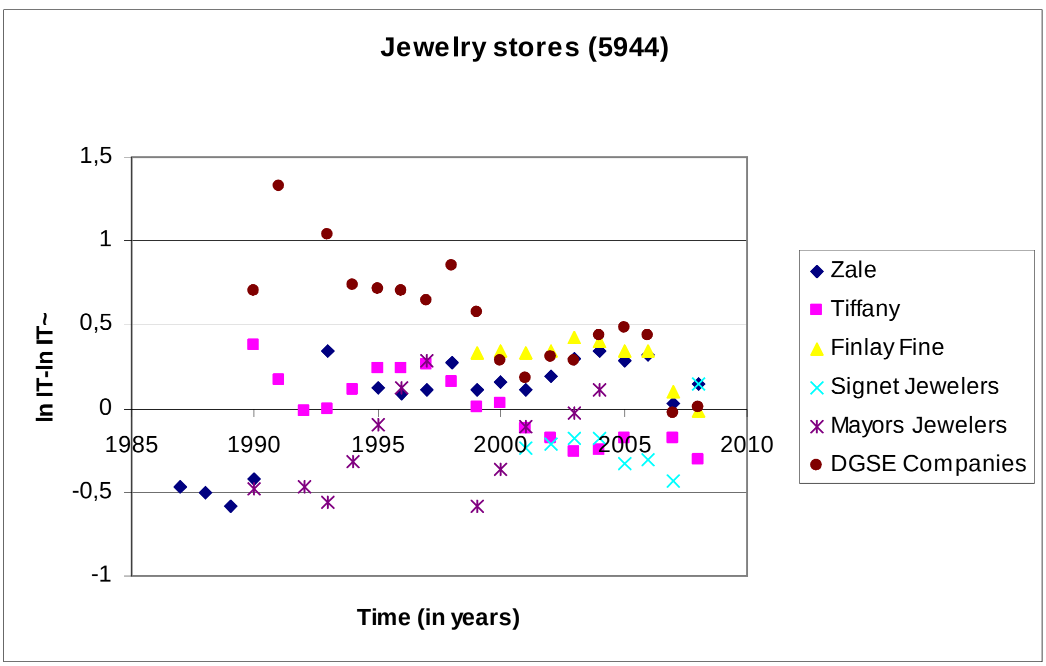


Figure 10: Illustration of Radio, TV, consumer electronic stores

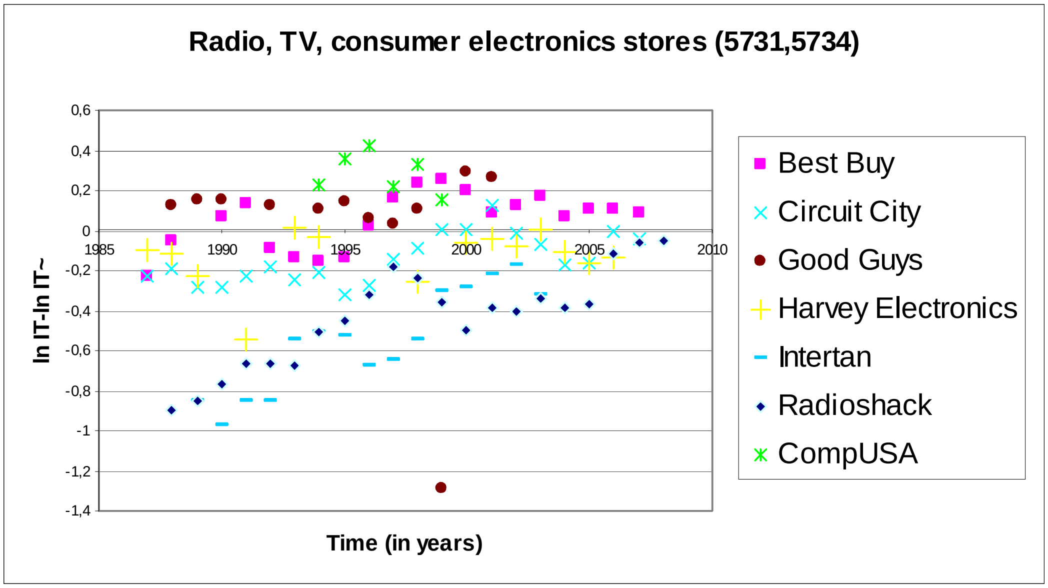
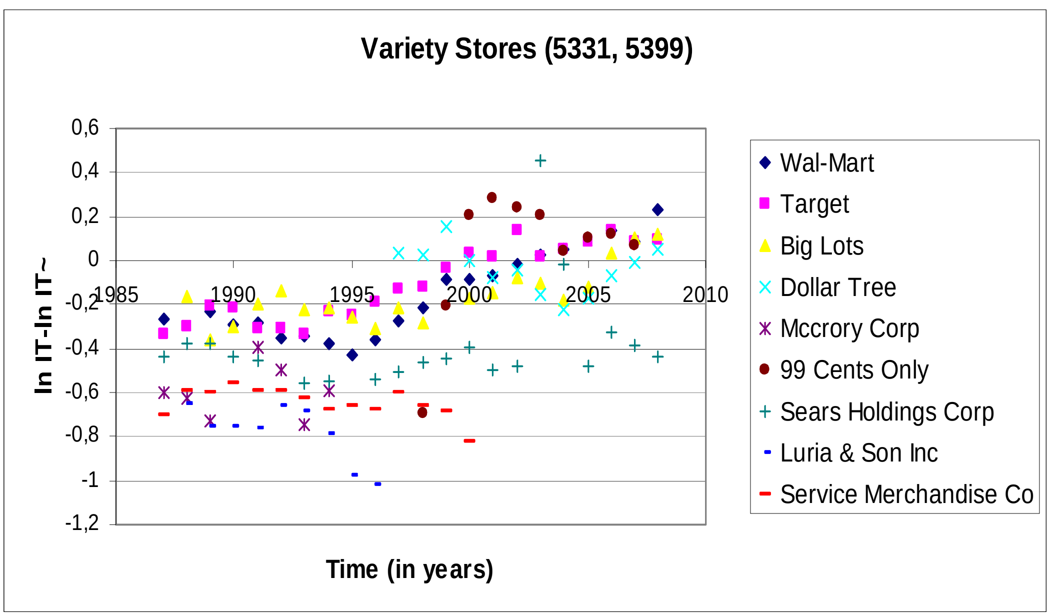


Figure 11: Illustration of variety stores



To sum up, all of our hypotheses are supported by the regression models that are provided above. We show that mean absolute percentage error in quarterly sales forecast is negatively correlated with inventory turnover ratio in most of the retail segments. In order to detect in which segment mean absolute percentage error is effective, we compare the following models: Model 1.1 to Model 1.3, Model 3.1 to Model 3.3, Model 1.2 to Model 1.4, and Model 3.2 to Model 3.4.

Model 1.1 vs. Model 1.3: After we add the MAPE as an explanatory variable to the Model 1.1, we obtain Model 1.3. The largest increase in R-sq (adj) is observed in "Hobby, toy, and game shops". Increase in R-sq (adj) is also seen in segments "Radio, TV, consumer electronics stores", "Variety stores" and "Department stores".

Model 3.1 vs. Model 3.3: After we add the MAPE as an explanatory variable to the Model 3.1, we obtain Model 3.3. The largest increase in R-sq (adj) is observed in "Home furniture and equipment stores". Increase in R-sq (adj) is also seen in segments "Jewelry stores", "Variety stores" and "Hobby, toy, and game shops".

Model 1.2 vs. Model 1.4: After we add the MAPE as an explanatory variable to the Model 1.2, we obtain Model 1.4. The largest increase in R-sq (adj) is again observed in "Hobby, toy, and game shops". Hypothesis 4 is strongly supported by the segments "Radio, TV, consumer electronics stores", "Variety stores" and "Department stores".

Model 3.2 vs. Model 3.4: After we add the MAPE as an explanatory variable to the Model 3.2, we obtain Model 3.4. The largest increase in R-sq (adj) is observed in "Hobby, toy, and game shops". We also detect that hypothesis 4 is supported by the segments "Home furniture and equipment stores", "Radio, TV, consumer electronics stores", and "Department stores".

Chapter 7

CONCLUSION

In this thesis, we use an empirical model to study the correlation between demand variability and inventory turnover rate. For this purpose, we develop a metric to measure inaccuracy of sales forecasts. This metric is mean absolute percentage error – MAPE of quarterly sales forecasts. In order to deterrmine the forecasts, we use Winter's triple exponential smoothing method individually by optimizing its three parameters to obtain the forecast for each firm. The empirical model is implemented on a sample financial data for 304 publicly listed U.S. retail firms for the 25-year period 1985-2009 which are obtained from Standard & Poor's Compustat database using Wharton Research Data Services (WRDS). The study in Gaur et al. (2005) is extended to a more recent and larger data set and tests to see whether the three hypotheses in Gaur et al. (2005) prevail with this data. In addition to gross margin, capital intensity, and sales surprise, we include MAPE of quarterly sales forecasts as an explanatory variable and analyze its impact. We use 5 different regression models to test our hypotheses and different explanatory variables in each of these models to understand the impact of four explanatory variables on inventory turnover ratio. The first model uses firm and time specific fixed effects because we desire to control the impacts of these to our regression model. The second model uses firm and time specific fixed effects as well; however, regression analysis is not carried out separately for each segment. The third model uses segment and time specific fixed effects to compare the significance of firm specific effects with segment specific effects. The fourth model uses segment and time specific fixed effects; nevertheless, regression analysis is not carried out separately for each segment. The last model uses just time specific fixed effects, and we do not carry out regression analysis separately for each segment.

Some key conclusions and insights drawn from these studies are as follows. We observe that in most of the sub-segments, except “Hobby, toy, and game shops”, “Home furniture and equipment stores”, of US retail industry, MAPE is negatively correlated with inventory turnover ratio. In many sub-segments, introducing MAPE helps to explain more of the variability of inventory turnover ratio across firms and across years. Furthermore, our results show that inventory turnover is negatively correlated with gross margin, and positively correlated with capital intensity and sales surprise which are consistent with those obtained by Gaur et al. (2005). In addition, according to the differences between actual inventory turnover rates and inventory turnover rates that are predicted by the regression models that we develop, we present some well-known retailers’ status to give insight into how well they are operating their inventory systems.

The study can be extended in many ways. One should investigate to see whether a more proper measure can be developed for demand variability. In this study, we use a statistical time series forecasting method to calculate the forecasts and their errors. An alternative way could be to use the forecasts that are developed by the firms or by independent financial analysts. Forecasts that are developed by the financial analysts are currently available, but only partially. A different approach could be to use other proxies such as number of SKUs a retailer manages to measure demand uncertainty. One can investigate the public availability of such data to develop better measures and to better understand the impact of demand uncertainty on retailer inventories. One of the explanatory variable, sales surprise which is the ratio of actual sales to sales forecast could be calculated with quarterly data as mean absolute percentage error, and the results of these could be compared.

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