THE EFFECT OF PRODUCT VARIETY AND INVENTORY LEVELS ON MISPLACED PRODUCTS AT RETAIL STORES: A LONGITUDINAL STUDY

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Abstract

From a four-year longitudinal study of 333 stores of a large retailer, we show that increasing product variety and inventory level per product is associated with an increase in misplaced products. We also show that increasing misplaced products at a store is associated with a decrease in store sales. Hence, we highlight a consequence of increased product variety and inventory level per product that had been previously overlooked in studies of retail product variety and inventory management. In addition, we make two contributions to the literature on quality management. One, we provide empirical evidence to support earlier assertions that higher product variety and inventory levels lead to an increase in defects. Two, we show empirical support for studies that demonstrated the beneficial impact of increased quality on firm performance.

1. Introduction

Using data from 333 stores of Borders Group Inc. (Borders), a chain of books and music superstores in the United States, over four years, we show that increasing product variety and inventory level per product at a store is associated with an increase in misplaced products. We also show that increasing misplaced products at a store is associated with a decrease in store sales. Hence, we highlight a consequence of increased product variety and inventory level per product that had been previously overlooked in studies of retail product variety and inventory management.

Our research was motivated by "phantom stockouts," the term used by the CEO of a large specialty retailer to describe situations where consumers are unable to find products that are, indeed, "available" at a store. An exploratory study at Borders showed that approximately one in six customers who approached a salesperson for help failed to find and purchase the title for which he or she was searching, not because the title was out-of-stock but rather because it was misplaced in a backroom, in other storage areas, or in the wrong aisle or location (Ton and Raman, 1999). This exploratory study provided evidence that misplaced products were frequent occurrences at Borders stores. Conversations with several other retailers, stories of customer experiences at various retailers, industry reports, and articles in industry journals suggested that misplaced products were common at most retailers. Andersen Consulting (1996) estimated that sales lost due to products that were present in storage areas but not on the selling floor amounted to $560-960 million per year in the US supermarket industry. A leading retailer of cosmetic products found that 60% of all stockouts at its stores were for products that were later found in the store but not where consumers could find them. Misplaced products are not limited to retail settings. For example, in 2002, 4% of incoming inventory at Amazon.com's warehouses were stored in the wrong place, down from 12% in 2000 (BusinessWeek, 2002). Not surprisingly, retailers have been seeking ways to reduce the occurrence of phantom stockouts at their stores.

Executives at Wal-Mart acknowledged the opportunity in this area when they announced that they were planning to bring more attention to in-store logistics (Saccomano, 1998).

Our problem evidently is of considerable practical significance, especially in retailing. In addition, our findings have substantial relevance to at least three streams of literature – one that seeks to optimize retail assortment and inventory levels, a second that looks at the drivers of quality, and a third that correlates quality levels with measures of firm performance (e.g., sales and productivity). We review the relevance of, and our contributions to, each of these streams of literature in section 2.

The rest of the paper is organized as follows: In the next section, we review the relevant literature and highlight the contributions of this study. In Section 3, we describe our research methodology. In section 4, we present our econometric model and in section 5, we present our results. We conclude our paper with a discussion of our findings.

2. Literature Review

Our paper contributes to, and draws upon, three steams of literature in operations management. Below we describe our contributions to each of these streams.

Optimizing retail product variety and inventory levels: Numerous papers have suggested techniques to optimize product variety and inventory level per product in retailing. A classic analysis of the impact of product variety in retailing is provided in Baumol and Ide (1956), who capture the tradeoff by pointing out that greater variety makes a store more attractive to consumers by increasing the probability of finding items that they want in the store, but also makes it less attractive by increasing the difficulty of shopping in the store. A number of papers in marketing consider models for product variety and shelf-space allocation (e.g., Corstjens and Doyle 1981, Zufryden 1986, Borin et al. 1994) in retail stores. Recent works (e.g., Van Ryzin and Mahajan (1999), Smith and Agrawal (2000)) have offered approaches to optimize retail product variety as well.

Considerable attention has also been paid to optimizing the level of inventory for each product. For example, the classic newsvendor problem is motivated by the decision problem for a newspaper retailer. Similarly, work on periodic and continuous review inventory models are at least partially targeted towards retailing. A review of inventory optimization approaches can be found in Silver, Pyke and Peterson (1998) and other texts on inventory management.

Most of the studies in these streams of literature trade off the added cost of additional inventory against the increased product availability that results from increasing product variety or inventory levels. These studies overlook the misplaced products that result from higher product variety and inventory levels, and the lost sales that result from misplaced products. As a result, we contribute to the models of retail product variety and inventory optimization by highlighting an additional consequence of increasing product variety and inventory levels.

Impact of Product Variety and Inventory Levels on Quality: Misplaced products are analogous to defects in quality management. At retail stores, each product has a specified location. The location of a product could be specified very precisely (e.g. at supermarkets each product has a specific slot) or more broadly (e.g. at discount apparel stores, products are supposed to be located somewhere within a section), depending on the retail store. We denote a product that is not in its specified location as a defect, in quality terms, because it fails to meet specification. By showing the effect of product variety and average inventory level per product on misplaced products, we offer empirical evidence to support earlier assertions that additional product variety and inventory levels lead to lower quality.

Consider first the relationship between product variety and quality. Fisher and Ittner (1999) show, using data from automotive assembly, that greater variability in option content is associated with an increase in rework rate. Earlier, Fisher *et al.* (1995) had argued that "the time for an assembly worker to access the correct part goes up with product variety, increasing the risk that the worker will choose the wrong part, resulting in quality problems and rework." Macduffie *et al.* (1996) and Yeh and Chu (1991) had also hypothesized a similar relationship, although they

did not find empirical evidence to support their hypotheses. Macduffie *et al*. (1996) argued that the relationship between product variety and quality needed to be investigated further. Hayes and Clark (1986) and Skinner (1974) also argued that increasing product variety would lead to greater "complexity" and "confusion" in a plant, which would be expected to contribute to lower quality.

Many authors have also argued that quality deteriorates at higher inventory levels. Lower inventory levels lead to better quality for two reasons. One, lower inventory leads to clearer and more timely feedback to various parts of the operating process in case of an error. Ocana and Zemel (1996), for example argue that operational learning is triggered by inventory shortages, which the authors describe as "operationally observable" events. Since the likelihood of inventory shortages is lower at higher inventory levels, the authors argue that production systems with higher inventory levels are likely to have fewer learning opportunities and hence, achieve lower quality over the long term. Two, by fostering greater accountability in operations, lower inventory causes various steps in the operating process to execute standard operating procedures more consistently (Alles et al., 2000). The detrimental effect of increased inventory levels on quality was central to the rationale for JIT Manufacturing or Lean Production Systems. Arguments for this assertion can be found in Schonberger (1982), Hall (1983) and Krafcik (1998).

Our examination of process details at Borders stores shows that the mechanisms by which product variety and inventory levels affect misplaced products are similar to the mechanisms identified in the literature reviewed above. As we argue in subsection 3.4, increasing product variety at Borders stores increases misplaced products by increasing complexity and confusion at the store. Similarly, increasing inventory level per product increases misplaced products by slowing feedback and decreasing accountability at the store.

Our contribution to the literature on the impact of product variety and inventory levels on quality is two-fold. One, prior literature has offered only limited evidence for the impact of product variety and inventory levels on quality. Our paper augments prior evidence. Two, most of

the prior studies have been in manufacturing. To our knowledge, this paper is the first to document the phenomenon outside of manufacturing.

Effect of Quality on Firm Performance: We show that reducing misplaced products at a store leads to an increase in sales. Consequently, our paper contributes to the literature that relates quality with firm performance. Some authors have related quality and productivity; examples include Hayes and Clark (1985), who related quality with total factor productivity, and Krafcik (1988), Ittner 1994, and Garvin (1988), who were able to relate quality with labor productivity. Krishnan et al (2000) demonstrate increases in life-cycle productivity from improved conformance quality in software products. Hendricks and Singhal (1997) examine the relationship between quality and multiple measures of firm performance. They show that firms that had won quality awards (i.e., had superior quality) outperformed those that had not, on operating income and sales growth.

3. Research Methodology

This section describes our research methodology. We introduce our research site in sub-section 3.1. In sub-section 3.2 we describe inventory management at Borders stores and in sub-section 3.3 we discuss misplaced titles at Borders stores and explain why misplaced titles are expensive in this context and analogous to defects in quality management. In sub-section 3.4 we generate our hypotheses and in sub-section 3.5 we describe our dataset.

3.1 Research Site: Borders Group, Inc.

We conducted our research at Borders Group, Inc. (NYSE: BGP), a Fortune 500 company and a well-known retailer of "entertainment products" such as books, CDs and videos. In 2002, Borders Group Inc. had approximately $3.5 billion in annual sales, $110 million in profit and employed about 30,000 people. At the end of 2002, the company operated 404 superstores (under the name "Borders"), and 778 mall-based stores (under the name "Waldenbooks"). In this study we focus solely on Borders superstores (hereafter we will call these "Borders stores").

Matching consumers with the products they desire to purchase is, and has always been, important to retailers. Borders, ever since it was founded, chose to emphasize this strategic thrust in the design of its merchandising systems, store layout and in-store technology, and human resource practices. We review these systems and processes briefly below; additional details can be found in Ton (2002) and Ton and Raman (2002).

Borders' merchandising system was designed in-house to determine, centrally, assortment and inventory levels for each store based on historical sales data. Borders' assortment varied substantially from one store to another. The company had devised proprietary algorithms to analyze sales data and identify appropriate inventory level for each title and assortment levels at each store. These algorithms were considered so powerful that Borders Group had considered licensing the software to other non-competing retailers (see Raff (2000) for a discussion of the importance of this merchandising system to the strategy of Borders).

Evidence for Borders' efforts to match consumers with the "right" title can also be seen in the design of its stores. Borders stores are designed to help consumers find the exact location of a title within the store. A typical Borders store has five Title Lookup computer terminals ("TLU") where consumers can identify the titles available at a store. The TLU also provides information on the specific section[1] in the store where the title is located. Since titles are supposed to be arranged alphabetically (by authors' name) within each section, the TLU system enables a consumer to find the precise location of every title available at a store. Consumers who are unable to find the title they are looking for can also turn to an information desk ("info desk") for help. Salespersons working at the info desk are instructed to walk with consumers to the relevant section and locate the title or offer to "special order" the title for delivery either at the store or at a location of the consumer's choice.

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[1]Borders stores are divided into 26 book sections (e.g. Children's, Parenting/Education, Literature/Poetry, History, Cooking) and 10 music sections (e.g. Classical, Soundtracks, New Age).

3.2. Inventory Management at Borders Stores

Figure 1 depicts a simplified process flow for inventory management at Borders stores. Borders stores receive daily shipments from the company's distribution centers. When a shipment arrives at a store, an inventory clerk, who works exclusively in the backroom, scans the boxes into the store's TLU system. The inventory clerk then opens the boxes and checks the shipment for accuracy. If there are discrepancies between what was sent and what was supposed to be sent to the store, the inventory clerk makes the necessary adjustments to the TLU. Once this inspection is complete, the inventory clerk assigns titles to different sections and shelves them in the temporary shelving area or on carts for transport to the selling floor.

Salespeople are primarily responsible for bringing new merchandise to the selling floor and for the general maintenance of their sections[2] during what is called section time. Standard operating procedures require that, for each title available at the store, there be at least one unit on the selling floor. As a result, in shelving new merchandise, salespeople try to ensure that each title has some presence on the selling floor. If there are multiple units of a title, salespeople, at their discretion, shelve some of these units on the selling floor and transfer the rest to storage areas, which are located in the backroom and on top of the shelves on the selling floor. If there is not enough space for all the new titles on the selling floor, salespeople, at their discretion again, remove extra units of existing titles to make room for new titles.

When units on the selling floor are sold, salespeople are supposed to replenish them by moving extra units from storage areas to the selling floor. At the end of each day, salespeople receive a "restocking report," indicating which titles from their sections had sold during the day. This report is designed to help them in this replenishment process.

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[2]An average salesperson is responsible for about 8,000 different SKUs in his or her section.

3.3 Misplaced Titles at Borders Stores

Errors in both shelving new merchandise and replenishing merchandise from storage may lead to titles that are present in storage areas but not on the selling floor. These "misplaced titles" are analogous to defects in quality because they represent titles that fail to meet specifications. A title meets specifications if at least one unit of it is available on the selling floor. To ensure that the assortment dictated by the merchandising system was carried out at each store, salespeople, as noted earlier, were required to stick to the centrally mandated assortment plan. Consequently, misplaced titles represent non-conformance with standard operating procedure at the store even if a salesperson deliberately places them in storage areas.

Titles that are misplaced in storage areas compromise the performance of Borders' merchandising system in two ways. First, misplaced titles reduce sales and labor productivity at a store. When a title is misplaced in a storage area, consumers who use the TLU to find the title on their own may be frustrated and, unless they seek help from a salesperson, will fail to complete their purchase. Consequently, misplaced titles lead to lost sales. In cases where consumers approach a salesperson for help, finding a misplaced title takes substantial time and affects labor productivity at the store. In either case, the misplaced title compromises the investment made by the company in installing the TLU, assigning titles to specific sections, seeking to arrange titles in alphabetical order within each section, and setting up "info desks" to help consumers navigate the store.

Second, titles that are misplaced in storage areas compromise the merchandising system's ability to observe demand patterns. As noted earlier, titles that are not on the selling floor but rather in storage areas can experience zero sales even if there is consumer demand for these titles. If the merchandising system is unaware that the title has been misplaced, it would incorrectly conclude that there is low demand for the particular title at that store, causing the system to allocate insufficient inventory or withdraw units that had been assigned to that store in the past.

3.4. Hypotheses

H1: Increasing product variety (number of titles) and inventory level per title at a store leads to more misplaced titles.

Consistent with extant theory in operations management, we hypothesize that defects will be higher when a store has greater product variety and higher inventory level per title. Other papers in the literature have, as we argued in section 2, presented some excellent arguments for expecting such a relationship. In this section, we provide further motivation for the hypothesis based on the processes for receiving, storing and replenishing merchandise at Borders stores.

Consider first the impact of higher variety on misplaced titles. Similar to claims that have been made in the literature, higher variety leads to more complexity and confusion at a store and hence, leads to more misplaced titles. For example, salespeople are required to move more units to storage areas when a store has more titles. The process of moving merchandise to storage areas and replenishing merchandise from storage areas, like most operational processes, is prone to errors. In other words, higher variety leads to additional steps in the process, and because each of these steps is prone to errors, higher product variety leads to more misplaced titles.

Now, consider the impact of increasing inventory levels per title at a store. As described in section 2, prior literature has argued that lower inventory levels lead to quicker feedback and fewer defects. This phenomenon, we hypothesize, occurs at Borders stores as well.

When there are more units of a title, salespeople are more likely to move units to the storage areas. Like other operational processes, shelving merchandise in the storage areas is prone to errors. For example salespeople might shelve title in the wrong place in the backroom.

When there are more units of a title in the store, it takes longer to detect these errors. At Borders stores, consumers are often looking for specific titles and thus salespeople for help when they cannot find what they are looking for. Consequently, consumers are constantly “auditing” or “inspecting” a store for titles that are misplaced at the store. The lapse between an employee misplacing a title in the storage areas and a customer requesting that title is longer when a store

has more units of the title. As Alles et al (2000) argued, slower feedback is likely to lead to less accountability and to cause employees to be more careless in shelving units in the storage areas. Consequently, we are likely to see more misplaced titles when a store has higher inventory level per title.

H2: Increasing titles not on floor (TNOF) at a store leads to a decrease in store sales

Customers experience phantom stockouts when titles that they wish to purchase are misplaced in storage areas, except in cases where salespeople check the storage areas for their requests and find the titles in the storage areas. Consumers at Borders stores often do not ask for help; Borders managers estimate that roughly 40% of customers at their stores do not ask for help. It is hard for a consumer to get help from a salesperson during heavy traffic periods. In addition, the TLU stations at the stores encourage customers to shop on their own. Even when customers ask for assistance, salespeople may not be able to locate the title in storage areas. The effort required to find a title in storage areas is substantial because the TLU stations do not report if the "available" title is located in storage areas or on the selling floor. Owing to the considerable effort in locating a misplaced title, salespeople often fail to devote sufficient time to locate a title in storage areas. Consequently, misplaced titles can lead to lost sales even when a customer approaches a salesperson for help. As a result, we hypothesize that increasing misplaced titles at a store will be associated with a decrease in store sales. Our hypothesis is consistent with studies that demonstrated the beneficial impact of increased quality on firm performance.

3.5. Data

We tested these hypotheses using data from 333 Borders stores from 1999 to 2002. Our dataset includes all Borders stores that opened before January 1st 2001. Because all our data come from a single retailer we are able to observe many establishments (333 stores) without needing to worry about across-firm heterogeneity. Moreover, using data from a single company allows us to have consistent measures in our empirical analysis.

Data on product variety, inventory levels, and misplaced titles were collected from physical audits conducted at each store by Borders' Internal Audit Department working in collaboration with a specialized third party. Store audits are performed once a year at each store between February and October; Borders deliberately avoids conducting audits during the busy sales period from November to January. Auditors count and track the location of each title in the store, and report the quantity, dollar value, and the number of titles that are available in the store as well as the quantity, dollar value, and the number of titles that are available in storage areas but not on the selling floor. All stores are closed during the audits.

We complemented our data collection with extensive fieldwork. We visited twelve stores and met with over 60 employees at many levels in the organization. Our fieldwork enabled us to understand store processes better. This understanding allowed us to generate our hypotheses and identify the necessary control variables that should be included in our analyses.

4. Empirical Model

We estimate the parameters of equation (1) to test the effect of product variety and inventory level per title on misplaced titles and the parameters of equation (2) to test the effect of misplaced titles on store sales. Equations (1) and (2) include several control variables. Below we describe the variables used in the models and explain why we used each of the control variables.

Notice that in both equations, we include store fixed effects. The store fixed effects allow us to control for unobserved heterogeneity across stores. Unobserved heterogeneity across stores may affect both the independent variables and the dependent variables in our models and lead to biased and inconsistent estimates of the parameters (Hausman and Taylor, 1981). For example, incompetent management at a store could result in both higher misplaced titles and lower sales. The store fixed effects control for all time-invariant aspects of a store, such as size, location, layout, etc. Consequently, to test our hypotheses, we conduct *within store* analyses. We

also include year-specific fixed effects to control for changes in economic conditions or changes in corporate policies over time.

$$TNOF_{it} = \alpha_i + \lambda_t + \beta_1\, Product\,Variety_{it} + \beta_2 Inventory\,Level_{it} + \beta_3 Seasonality_{it} + \beta_4 Unemployment_{it} + \beta_5 Labor_{it} + \beta_6 FT\,Turnover_{it} + \beta_7 PT\,Turnover_{it} + \beta_8 SM\,Turnover_{it} + \varepsilon_{it} \quad (1)$$

$$Sales_{it} = \delta_i + \phi_t + \gamma_1 TNOF_{it} + \gamma_2\, \ln(Product\,Variety)_{it} + \gamma_3 \ln(Inventory\,Level)_{it} + \gamma_4 Seasonality_{it} + \gamma_5 Unemployment_{it} + \gamma_6 Labor_{it} + \gamma_7 FT\,Turnover_{it} + \gamma_8 PT\,Turnover_{it} + \gamma_9 SM\,Turnover_{it} + \gamma_9 Competition_{it} + \varepsilon_{it} \quad (2)$$

$\alpha_i, \delta_i = Fixed\ effect\ for\ store\ i, i = 1, 2 \ldots, 333,\ in\ equations\ (1)\ and\ (2)\ respectively$
$\lambda_t, \phi_t = Fixed\ effect\ for\ year\ t, t = 1999, 2000, 2001, 2002\ in\ equations\ (1)\ and\ (2)\ respectively$

Below we describe the variables used in all three equations.

TNOF: The measure for misplaced titles, "titles not on floor (TNOF)," represents the number of titles in storage areas but not on the selling floor at store *i* in year *t*. TNOF does not include those titles that are available in storage areas *and* on the selling floor. Moreover, it does not count the *number of units*, instead it merely counts the number of titles that are in storage areas and not on the selling floor. For example, **Table 1** shows a simplified store with two titles. In this store, TNOF is one since there are two titles in the store, one of which, Title "B," is not available on the selling floor. Title A is available on the selling floor and hence, is not counted as a "title not on floor (TNOF)."

Sales: In measuring store sales, we had to choose an appropriate time period for sales so that the TNOF during the physical audits would be representative of the TNOF during that sales period. Since we had access to monthly sales data, we chose sales during the month preceding the audit as the appropriate time period. We did not include sales during earlier months since misplaced titles during those months could be higher or lower than misplaced titles during the physical audit

period. Similarly, we did not include sales during months following the physical audits since stores are expected to reduce misplaced titles right after the physical audits. Consequently, our dependent variable in equation (2) is sales during the month preceding the audit at store *i* in year *t*[3].

Product Variety: Product variety is measured as the total number of titles at store *i* at the time of the physical audit in year *t*. Product variety is one of the two main variables of interest in equation (1). We use product variety as a control variable in equation (2) because several authors have argued that increasing the number of products at a store increases the probability that a customer will make a purchase at the store (e.g. van Ryzin and Mahajan, 1999). Consequently, we would expect higher sales at a store when there are more products at the store. To take into account expected decreasing returns to increasing product variety, we use the natural log of product variety in equation (2).

Inventory Level: Inventory level is measured as the average number of units of inventory per title at store *i* at the time of the physical audit in year *t*. Inventory level is one of the two main variables of interest in equation (1). We use inventory level as a control variable in equation (2) because increasing the inventory level for a particular product increases fill rates for that product (see for example Silver, Pyke, and Peterson, 1998). Consequently, we would expect higher sales at a store when the average inventory level is higher at the store. To take into account expected decreasing returns to increasing inventory level per title, we use the natural log of inventory level in equation (2).

Seasonality: Expected customer demand at Borders stores varies throughout the year; for example, December is always the busiest month and April tends to be busier than August at most

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[3]We considered an alternate model where we used sales during the three months preceding the audit at store *i* in year *t* as the dependent variable. The results were very similar.

Borders stores. When stores are audited during high traffic periods, they may have higher TNOF simply because salespeople have to dedicate a greater portion of their time to assist customers and less than adequate time to replenish merchandise from storage areas. Similarly, we would expect higher sales at a store during April, simply because it tends to be a busier period. We use a seasonality index, derived from monthly sales data, to control for seasonality in equations (1) and (2).

Let S_{ijt} =sales at store i in month j in year t. Then the seasonality index for month j is

$$\theta_j = \frac{\sum_{t=1}^{4}\sum_{i=1}^{267} S_{ijt}}{\left(\sum_{t=1}^{4}\sum_{j=1}^{12}\sum_{i=1}^{267} S_{ijt} \Big/ 48\right)}.$$

Unemployment Rate: When labor markets are tight, stores may have difficulty attracting high quality employees and might consequently have higher TNOF or lower sales. We use unemployment rate of the metropolitan statistical area[4] in which the store is located during the month preceding the audit at store *i* in year *t* to control for differences in labor market conditions in equations (1) and (2).

Labor: It is understandable that increasing the amount of labor in a store could reduce TNOF and potentially increase sales. Given the large number of tasks for which salespersons are responsible, it is not surprising that they occasionally fail to move appropriate titles promptly from storage areas to the selling floor. Such slip-ups are less likely at times where the employees have less work to do. Similarly, when salespersons have less work to do, they may be more attentive to customers, and encourage more sales. We use labor as a proxy for employee workload

[4] Source: Bureau of Labor Statistics

in equations (1) and (2) and measure it as payroll expenses during the month preceding the audit at store *i* in year *t*.

Employee Turnover: As employees spend more time at the stores, they become more familiar with the titles in their sections and become better at noticing those that are missing from the selling floor. Such "tacit knowledge" (Polanyi, 1966; Nelson and Winter, 1982) is common in many operating environments and is difficult to transfer from an old to a new employee. Consequently, we would expect higher TNOF when employee turnover is higher at the stores. Similarly as employees spend more time at the stores, they become more effective in assisting customers. As a result we would expect lower sales when employee turnover is higher at the stores. We use two measures to track employee turnover among those employees that are charged with managing inventory. Our measures track turnover among floor salespeople, their immediate supervisors, and inventory clerks but exclude turnover among office coordinators, training managers, store manager, and community relations coordinators. Our first measure, full-time employee turnover, is the fraction of full-time employees that had left during the month preceding the audit at store *i* in year *t*. Our second measure, part-time employee turnover, is the fraction of part-time employees that had left during the month preceding the audit at store *i* in year *t*. We separate part-time and full-time turnover even though these employees often perform similar tasks because the impact of the departure of a part-time employee may be different than that of a full-time employee's departure.

Store Manager Turnover: Over time, store managers develop an understanding of processes and people at their stores. This understanding helps in managing the movement of titles from storage to floor and also in managing customer service at the stores. For example, experienced store managers are aware of individual employees' strengths and weaknesses, and hence, are able to monitor and remind some employees to move merchandise promptly or be more attentive to customers. Consequently, we would expect higher TNOF and lower sales after a store manager's turnover. Store manager turnover is a dummy variable in equations (1) and (2) that has a value of

1 if the store manager had left the company voluntarily since the last physical audit at store *i* in year *t.*

Competition: We would expect lower sales at a store when there are more competitors in the area. Consequently in equation (2), we include the number of competing stores in the area as a control variable. We use Borders management's judgment in what constitutes competition for an existing Borders store. Managers at Borders consider Barnes & Noble and other Borders stores in the area as the main competitors to a specific Borders store. Consequently, they track the opening, and closing, of Barnes & Noble and other Borders stores near existing Borders stores. We use these data to calculate the total number of Barnes & Noble and Borders stores in the area during the month preceding the audit at store *i* in year *t*.

4.1. Model Estimation

We estimate the parameters of equations (1) and (2) using ordinary least squares (OLS) estimators. Equations (1) and (2) form a triangular system; the endogenous variable, TNOF, is determined by a set of exogenous variables in equation (1), and Sales is determined by TNOF (the endogenous variable) and exogenous variables. The equations in a triangular system can be consistently estimated using equation-by-equation OLS as long as the residuals from the equations are not correlated (Greene, 2000; Kennedy, 1998). We did not detect correlation between the residuals. The Pearson correlation between the residuals from equation (1) and the residuals from equation (2) is 0.004, with a p-value of 0.89.

The OLS estimates of the parameters are reported in the second columns of **Tables 3** and **4**. Inspection of the scatter plot of residuals as well as White's test revealed heteroskedasticity in the error terms in equation (1). Consequently, we report the heteroskedasticity robust standard errors for OLS, as suggested by Huber (1967) and White (1980). Since our data contained observations across stores, it is possible that the variance of ε_{it} varies across stores. As a result, in addition to OLS, we consider a flexible structure of the variance covariance matrix of the

errors with store-wise heteroskedasticity and estimate the parameters of (1) using feasible generalized least squares (FGLS) estimators (Greene, 2000). The FGLS estimates of the parameters are reported in the third column of **Table 3**.

We did not detect heteroskedasticity in the error terms in equation (2). The Durbin-Watson statistic to check for autocorrelation, however, revealed autocorrelation in the error terms. Consequently, in addition to OLS, we consider a flexible structure of the variance covariance matrix of the errors with first-order autocorrelation and estimate the parameters of (2) using Maximum likelihood estimation (MLE). We use Beach and MacKinnon's (1978) algorithm to solve the MLE problem. See Greene (2000) for details about this estimation methodology. The MLE estimates of the parameters are reported in the third column of **Table 4**.

5. Results

Summary statistics for all variables used in the analyses are reported in **Table 2**. The regression results to test the first hypothesis are reported in **Table 3**. The results of OLS and FGLS regressions are very similar and confirm the first hypothesis. Increasing both product variety and inventory level per title at a store is associated with an increase in TNOF. Both variables are significant at one percent level. The regression results to test the second hypothesis are reported in **Table 4**. The results of OLS and MLE regressions are very similar and show that an increase in TNOF is associated with a decrease in store sales. TNOF is significant at five percent level in the OLS regression and one percent level in the MLE regression[5].

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[5]We verified our results with an alternate model where we relied on management's forecasted sales for each store in a given month. Borders managers forecast monthly store sales using the factors that they believe affect store sales. In our alternate model, we specified "sales surprise", defined as deviation from management's forecasts as a function of TNOF at the store. TNOF had a negative sign and was significant at 5% level.

Table 5 interprets our results. It shows the increase in TNOF from a 10% increase in product variety and inventory level per title at a hypothetical store that, on average, carries 178,711 titles and 1.37 units per title. **Table 5** also shows the effect of these increases in TNOF on store sales. All else being constant, adding 17,871 more titles to the store increases TNOF by 965 units. This increase in TNOF is associated with a $18,528 decrease in annual store sales. All else being constant, adding 24,590 more units to the store (increasing the inventory levels by 10%) increases TNOF by 1,090 units. This increase in TNOF is associated with a $20,928 decrease in annual store sales (approximately 0.35% of store sales).

6. Discussion

We show that increasing product variety and inventory level per product at a store leads to an increase in misplaced products. We also show that misplaced products lead to lost sales, and hence, affect store profitability. By highlighting a consequence of increased product variety and inventory levels that was previously ignored, we contribute to the literature and practice on retail product variety and inventory management.

Our findings are likely to be of even greater practical significance as variety levels continue to rise in many sectors of retailing (see Ketzenberg et al, 2000 for a discussion of "dense retail outlets"). In book and music retailing, variety has grown steadily because even though new books for example are constantly being written and published, consumers continue to purchase older books. Not surprisingly, the number of book titles available for purchase has increased steadily; Amazon.com, an on-line retailer, claims to have over three million titles in stock, superstores owned by chains like Borders and Barnes and Noble carry close to 180,000 titles at a single location. Growing variety, our analysis shows, is likely to lead to even higher misplaced products and phantom stockouts, thus leading to increased importance for the phenomenon we are studying.

We do not argue that merchandise planners at retail chains necessarily ought to decrease either product variety or inventory levels at their stores in order to reduce the frequency of misplaced products. It is important, however, for them to be aware that one of the consequences of increasing product variety or increasing inventory levels is that the problem of misplaced products and the resulting lost sales will be exacerbated.

Our study also makes two contributions to the literature on quality. One, we provide empirical evidence to support earlier assertions that higher product variety and inventory levels lead an increase in defect rates. Two, we show empirical support for studies that demonstrated the beneficial impact of increased quality on firm performance.

Table 1. A simple example to illustrate how TNOF is calculated

	TITLE	
	A	**B**
Number of units on floor	1	0
Number of units in storage	3	2
TNOF	0	1

Table 2. Descriptive statistics for all variables from a sample of 333 Borders stores over four years

Variable	**N**	**Mean**	**Min.**	**Max.**
TNOF	1122	5791.77	251.00	23563.00
SALES ($)	1093	508887.31	164002.66	1583556.00
PRODUCT VARIETY (titles)	1091	178711.45	102082.00	319674.00
INVENTORY LEVEL (units/title)	1089	1.38	1.10	1.88
SEASONALITY				
UNEMPLOYMENT (%)	973	4.19	1.30	15.70
LABOR ($)	1092	61359.18	17846.14	206498.88
FULL TIME TURNOVER (%)	973	0.06	0.00	0.78
PART TIME TURNOVER (%)	973	0.10	0.00	1.20
SM TURNOVER				
COMPETITORS (#)	1137	0.80	0.00	5.00

Table 3. Regression results for testing the effect of inventory levels and product variety on TNOF.

	Dependent Variable: TNOF	
	(1)	(2)
	OLS	FGLS
PRODUCT VARIETY	0.05 ***	0.06 ***
	-0.01	-0.01
INVENTORY LEVEL	7,920.61 ***	7,847.15 ***
	-2,273.13	-778.11
SEASONALITY	-808.72	14.54
	-1,288.93	-581.06
UNEMPLOYMENT	-130.74	-59.91
	-133.78	-70.16
LABOR	-0.03 **	-0.02 ***
	-0.01	-0.01
FT TURNOVER	494.46	582.54
	-1,573.49	-752.72
PT TURNOVER	1,147.66	1,554.25 ***
	-728.78	-399.30
SM TURNOVER	236.78	161.22
	-284.82	-112.63
YEAR 1999	-1,552.82 ***	-1,828.68 ***
	-485.97	-209.18
YEAR 2000	-918.35 **	-1,105.48 ***
	-460.94	-207.28
YEAR 2001	-1,069.83 ***	-1,181.66 ***
	-371.96	-168.28
Observations	949	949
$F_{276,672}$ Statistics	4.60 ***	
Adjusted R^2	0.51	

*Note: *,**,*** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Store fixed effects are included in the regressions but not shown in the table. Standard errors are reported in parenthesis. Standard errors in (1) are heteroskedasticity robust.*

Table 4. Regression results for testing the effect of TNOF on store sales

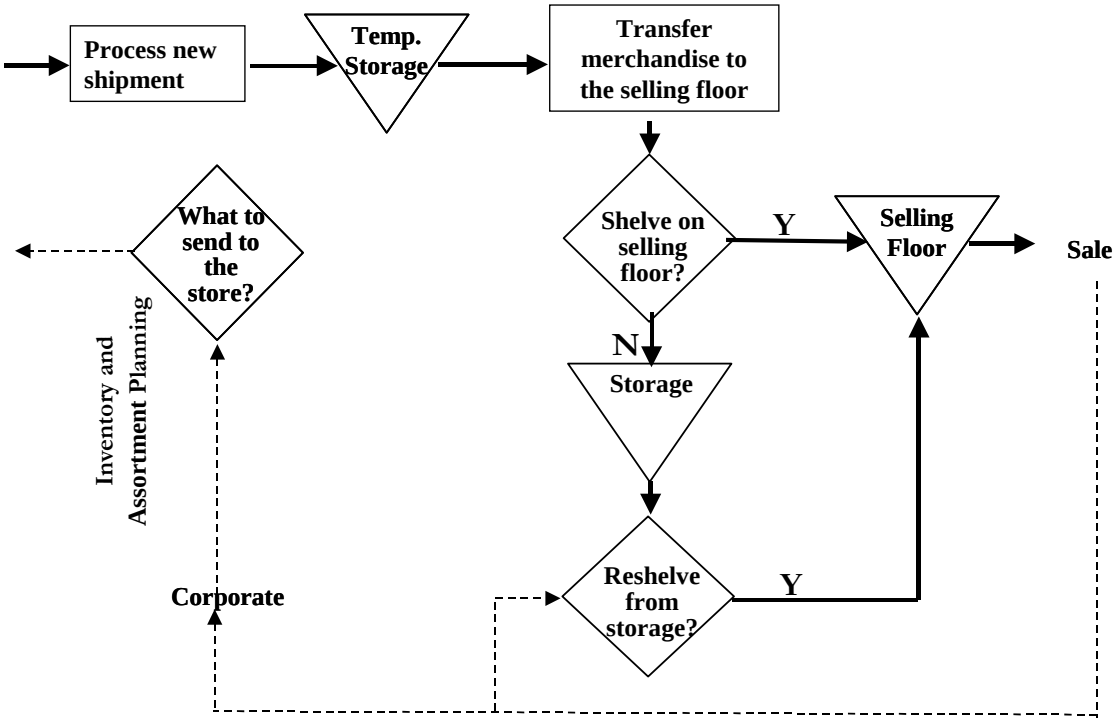
	Dependent Variable: Sales	
	(1)	(2)
	OLS	MLE
TNOF	-1.60 **	-1.68 ***
	-0.77	-0.65
LN(PRODUCT VARIETY)	104,034.52 ***	106,578.00 ***
	-26,788.42	-22,339.00
LN(INVENTORY LEVEL)	66,576.66 **	72,927.00 ***
	-33,517.35	-28,423.00
SEASONALITY	400,089.10 ***	394,404.00 ***
	-12,927.20	-11,013.00
UNEMPLOYMENT	-3,903.32	-4,021.20 *
	-2,884.42	-2,442.53
LABOR	2.24 ***	2.38 ***
	-0.22	-0.19
FT TURNOVER	23,022.23	26,584.00
	-28,124.77	-24,476.00
PT TURNOVER	-13,631.52	-11,804.00
	-16,393.15	-14,273.00
SM TURNOVER	-4,437.86	-5,447.72
	-4,990.47	-4,301.54
COMPETITORS	-64,497.91 ***	-64,634.00 ***
	-5,868.98	-4,919.47
YEAR 1999	-25,910.29 ***	-27,771.00 ***
	-8,616.43	-7,276.23
YEAR 2000	-18,039.23 **	-19,998.00 ***
	-7,936.98	-6,685.88
YEAR 2001	-15,799.15 **	-17,447.00 ***
	-6,704.17	-5,804.62
Observations	949	949
$F_{278, 670}$	65.23 ***	
Adjusted R^2	0.95	

*Note: *,**,*** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Store fixed effects are included in the regressions but not shown in the table. Standard errors are reported in parenthesis.*

Table 5. Interpretation of results from OLS estimates reported in **Tables 3** and **4**

Variable	Mean	Increase in TNOF from a 10% increase in independent variable	Decrease in monthly sales from resulting increase in TNOF	Decrease in annual sales from resulting increase in TNOF
PRODUCT VARIETY (titles)	178711.45	965.04	$1,544.00	$18,528.00
INVENTORY LEVEL (units/title)	1.38	1089.87	$1,744.00	$20,928.00

Figure 1. Simplified process flow for inventory management at Borders stores



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