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Relationships between inventory, sales and service in a retail chain store operation

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Abstract
Effective inventory management is critical to retailing success. Surprisingly, there is little published empirical research examining relationships between retail inventory, sales and customer service. Based on a survey of 101 chain store units, this paper develops and tests a series of hypotheses about retail inventory. Seventy-five percent of the store owners/managers responded to the mail survey. As expected, significant positive relationships were found between inventory, service and sales. Specifically, support was found for the theory that inventory is a function of the square root of sales. Also, greater product variety leads to higher inventory, and service level is an exponential function of inventory. Finally, demand uncertainty was found to have no apparent effect on inventory levels.

Introduction
Among retail practitioners, there is growing interest in inventory management/sales data systems, which help stores make the most of merchandise assortments and scarce shelf space (Orenstein, 1999). According to Coopers & Lybrand, major areas of efficient consumer response (ECR) activity in the grocery business include: sales forecasting and statistical management of safety stock (Retail World, 1997). Best practices in retail inventory management call for a proper balance between inventory and service levels, recognition of the importance of merchandise availability, and accurate store sales/inventory data (Wilson et al., 1995). Thus, it is surprising to find very little empirical research on relationships between inventory, sales and service in the retail and logistics literature.

This paper quantifies relationships between inventory, sales and service level (e.g. availability). Interfirm variations in assortment, retail sector and other characteristics are controlled by analyzing observations from a single chain. Stores in this chain make buying decisions independently and
receive stock directly from suppliers, rather than through a corporate distribution center. Still, between-store variation in the variables allows for investigation of hypothesized relationships. Control variables include product variety and demand uncertainty.

The paper is organized as follows. In the second section, relevant literature is reviewed and the research hypotheses are developed. Then, the third section describes data collection procedures and the data set. The fourth section presents statistical results. Finally, the paper closes with conclusions and a discussion on implications of the results.

Conceptual development

Inventory management is critical to retail financial performance. Nevill et al. (1998) note: on nearly every merchant’s balance sheet, inventory tops the list of valuable physical assets. After cost of goods sold, the major costs incurred by retailers involve the resource trinity - space, labor and stock (Lusch, 1986; Larson and Lusch, 1990). Thus, important measures of retail efficiency are sales per square foot, sales per employee, and stock turnover. Inventory (a.k.a. stock) provides product availability, a key dimension of customer service (LaLonde and Zinszer, 1976; Copacino, 1997). Stockouts (lack of availability) bring lost sales, backorder costs, delayed cash flow - and lost customers.

A literature search found most work to be theoretical, rather than empirical, with hypothetical examples or single practical applications. A large body of normative inventory theory offers optimal order quantities, safety stock levels and inventory control procedures, given assumptions about demand, lead time and cost structures (Tersine, 1994; Sherbrooke, 1992). An early example is the classic economic order quantity (EOQ) model, which Erlenkotte (1989) traces back to Harris (1913).

Some researchers have modeled specific inventory management factors or situations, such as centralization of inventories (Maister, 1976), re-order points (Lau, 1982), net present value (Kim et al., 1984) and the management of spare parts (Lawrenson, 1986). Others discuss a wide range of analytical inventory management techniques (Howard, 1984). However, as noted above, all these contributions are theoretical rather than empirical.

A more recent example is Urban’s (1998) generalization of inventory-level dependent demand models, and merging of these with assortment/shelf-space allocation models. Further recent theoretical contributions include: modeling the effect of lead time on safety stock (Evers, 1999), modeling inventory as the independent variable and a predictor of sales (Larson and DeMarais, 1999), and developing solutions for certain <Q,r> inventory models (Namit and Chen, 1999).

Still, there is very little empirical verification of relationships between factors that impact inventory levels - and relationships between inventory, customer service and sales. The next section starts with a review of published empirical findings on retail sales and inventory.

Determinants of retail sales

The empirical literature on retail inventory consistently models stock as a determinant of retail sales. Other previously-modeled determinants of retail sales include merchandise variety, number of employees, hours of operation, store size and number of competitors.

Baumol and Ide (1962) found significant, positive links between sales, the dependent variable, and both inventory levels and merchandise variety. Morey (1980) gathered sales and service level data from 61 United States Government-run Navy Commissaries. Using nonlinear regression, he reported
a positive relationship between sales and service (number of employees and hours of operation). Morey called for further research using range of items and in-stock rate (i.e. variety and availability) as service measures.

Hise et al. (1983) studied 132 chain store units offering non-clothing items in shopping malls. Using linear regression, they found inventory levels and number of employees to be positive predictors of sales. Store size was inversely related to sales, and number of competitors had no significant impact. Hise et al. suggested that future research should use nonlinear regression, and focus on other retail sectors, e.g. grocery, department and drug stores.

Good (1984) studied 64 grocery stores in Ontario and another 32 stores in Newfoundland. In his productivity (output/input) model, outputs included sales and number of transactions; inputs included store size and number of employees. Using value added/man-hour as the dependent variable, he concluded size of store to be the best predictor of productivity across stores. Larson and Sjibrands (1991) used aggregate Statistics Canada data, covering all Canadian chain stores, to assess the impact of quick response (QR) retail strategies on stock/sales ratios. They reported a significant, negative link between QR and stock/sales, but no relationship between interest rates and stock/sales ratios.

Ingene and Lusch (1999) estimated a production function for American department stores. They gathered secondary data on stores in 245 standard metropolitan statistical areas (SMSAs). Positive, significant relationships were reported between sales per store (the dependent variable) and both total store floor space and employee labor hours.

**Does stock determine sales - or vice versa?**

Larson and DeMarais (1999) describe various categories of stock carried at retail, in detail. In addition to cycle and safety stock, they discuss pipeline and psychic stock. Pipeline stock is inventory en route from supplier (factory, wholesaler, distribution center) to the store. Psychic stock is in the store, on the shelf. It is display inventory carried to stimulate sales. Thus, psychic stock is an independent variable category of inventory - and a determinant of sales.

Store inventory decisions include: how much to order, when to order and how much safety stock to carry. Retail inventory management is often based on EOQ principles. The term model stock refers to the planned level of store inventory. Cycle stock services demand under conditions of certainty, when it is inefficient to ship products just in time, i.e. one at a time. Thus, anticipation of demand determines cycle stock. Lot size or cycle stock is a function of inventory carrying costs, order processing costs - and sales or usage rate. Now, sales is the independent variable, and stock is the dependent variable. Safety stock services demand under conditions of uncertainty. Again, demand (a.k.a. sales) is a determinant of stock.

Theoretically, cycle stock is a function of the square root of sales, as calculated with the EOQ model:
Since the chain under study operates on the model stock concept, most of the inventory in stores should be cycle stock. This leads to the first hypothesis:

H1: Inventory increases by the square root of sales.

Product or merchandise variety increases inventory levels since more stock-keeping units (SKUs) must be carried. If new items complement other items in the assortment, variety also increases sales. Lambert et al. (1998) demonstrate how the addition of an acceptable substitute item increases service level, in terms of availability. Also, if new items are substitutes for other items, competing for consumer dollars, greater variety tends to draw more customers into the store. As demonstrated above, more stock is needed to cover the anticipation of higher sales. Thus, the second hypothesis is:

H2: Greater product variety results in higher inventory levels.

The survey included two measures of product variety. Store managers were asked to compare their stores with others in the chain, in terms of number of cosmetics and front store SKUs (front store is the term used for all items other than cosmetics and pharmacy items). These survey items are shown in the Appendix, Table AI. The two measures are highly related (correlation = 0.57; p-value = 0.000), though cosmetics account for only 11 percent of sales on average. Thus, for hypothesis testing, only the front store variety variable is used.

Theoretically, safety stock is a function of demand variability. When demand and lead time distributions are known, safety stock can be calculated with the following model:

$$SS = k(t^2 + \bar{r}^2)^{1/2}$$  \hspace{1cm} (3)

Where $k = \text{service level objective}$

$t = \text{average lead time}$

$s_d = \text{standard deviation of demand}$

$s_r = \text{standard deviation of lead time}$

$r = \text{average demand or usage rate}$

Thus, greater demand variability causes a store to increase safety stock levels, to achieve a given level of service. This inspires the following hypothesis:

H3: Greater demand uncertainty results in higher inventory levels.
Three survey items focused on demand uncertainty. Respondents were asked to rate stability of volume, accuracy of projections (forecasts), and predictability, in terms of the business climate they face. These items are shown in the Appendix, Table AII. Factor analysis of these items extracted a single factor (see Table I), accounting for 71.2 percent of total variance. Since volume stability most closely matches the concept of demand uncertainty, it alone is used for hypothesis testing.

The stock/service relationship
A strategic retail decision involves the level of customer service the firm plans to provide. Service level is often measured by stock availability, but could also be measured by order cycle time or consistency of cycle time. For example, a store could have a customer service objective of 99 percent stock availability.

Johnson et al. (1999) describe the exponential relationship between inventory and service levels. By increasing stock levels, a store generally provides higher service levels to its customers. But, at some point, large increases in inventory yield relatively small gains in customer service. The next hypothesis to be tested is:

H4: Service level increases with inventory, at an exponential rate.

Leading texts in inventory management (e.g. Tersine, 1994) and logistics management (e.g. Lambert et al., 1998) diagram the stock/service level relationship. If demand is assumed to follow a normal distribution, then service increases with stock at a decreasing rate - and (theoretically) an infinite amount of inventory (I) is needed to assure a perfect, 100 percent service level (SL). This scenario seems to fit the following exponential function:

\[
SL = 1 - e^{-I/B}
\]

where B = a regression parameter.

Lambert et al. (1998, pp. 139-43) present an example in which demand is normally distributed, safety stock is set using equation (3), and average inventory equals equation (2) plus equation (3). Figure 1 depicts the stock/service relationship in this example. An exponential function, as shown in equation (4), describes the relationship rather well (R-squared = 0.63).

Respondents were asked six questions on their perceptions of service level provided. Specifically, they were asked how frequently customers comment on the availability of: new/extended products, house brands, items not carried, advertised items, environmentally friendly or green items, and sale priced items (see Appendix, Table AIII). Assuming customers comment mostly on lack of availability, more frequent comments imply lower service level. Availability of all but advertised and sale priced items reflect merchandising decisions (what to carry) rather than inventory decisions (how much to carry).
In a factor analysis of the six variables, advertised items and sale priced items converged to form one factor, while the other four items converged to form another factor, as shown in Table II. The two factors account for 42.9 and 18.3 percent of variance. Factor 2 is expected to best represent service level, and to be negatively related to inventory level (recall that it represents lack of availability). The sum of the two variables aligned with Factor 2, advertised items and sale priced items, is used for hypothesis testing.

Data collection
Data were collected in two stages. In the first stage, a region of the chain, covering 101 stores, provided access to management information system (MIS) data for store size, sales, and stock levels.

The second stage was a mail survey sent to all 101 store managers asking a number of questions on retail operations (including questions covered by the MIS). The survey was mailed along with a two-dollar incentive and covering letters from the first author and the chain's regional manager. The instrument was developed in consultation with the regional manager, and was pre-tested with several store management experts. After editing, the final version was mailed to store managers, and the regional manager sent an e-mail message urging response to the survey.

The unit of analysis was the store, and respondents were store owners/managers. These managers deal with suppliers, choose items (from the chain's merchandise list) and decide order quantities. Managers also receive training and periodic briefings on store performance compared to other stores in the region. Surveys were sent to a single respondent for each store, since the owner/manager was always the most qualified informant. Table III is a brief profile of the survey respondents.

Since data were collected from stores in a single chain, strategic inventory decisions were similar across sample units. Similar vendors and channels supply each store. Assortments are also similar across stores, but vary to please local tastes. Thus, individual store performance should be
dependent on store decisions and local competitive environments. Table IV shows a summary of store characteristics.

A total of 72 complete and usable surveys were returned. No follow-ups were done, although store size, location and sales data were compared to known distributions and no patterns were found in observations with missing data. The level of support provided by the chain was instrumental in gaining a high response rate. In addition, the survey was administered just after the financial year-end, when managers had time to participate and the information requested was close at hand.

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>New/extended products</td>
<td>0.88</td>
<td>0.10</td>
</tr>
<tr>
<td>House brands</td>
<td>0.75</td>
<td>0.14</td>
</tr>
<tr>
<td>‘Green’ items</td>
<td>0.55</td>
<td>0.20</td>
</tr>
<tr>
<td>Items not carried</td>
<td>0.47</td>
<td>0.11</td>
</tr>
<tr>
<td>Sale price items</td>
<td>0.08</td>
<td>0.53</td>
</tr>
<tr>
<td>Advertised items</td>
<td>0.35</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Table II. Availability factor analysis (rotated matrix)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days/week in store</td>
<td>15.5</td>
<td>1</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>Years with firm</td>
<td>10.5</td>
<td>1</td>
<td>23</td>
<td>72</td>
</tr>
<tr>
<td>Years as manager</td>
<td>5.8</td>
<td>1</td>
<td>23</td>
<td>72</td>
</tr>
</tbody>
</table>

Notes: * 19 respondents answered in terms of hours, not days

Table III. Store manager (survey respondent) characteristics

The survey and MIS data provided indicators of the constructs shown in Table V. Survey data were compared to MIS data, where both were available, to assess validity of the instrument. Pearson correlations of sales, inventory and store size, as reported on the survey with those from the MIS, are all significant (see Table VI). These results suggest that survey items are a good reflection of in-store retail reality. One can feel confident using data from either source. Thus, MIS data will be used where available, and survey data will be used where no equivalent MIS data exist.
Statistical results

Table VII shows results of using the current data set for replicating the Hise et al. (1983) regression model. Stock and labor are positive, significant predictors of sales. Moreover, store size has an inverse relationship with sales and competitive intensity is not significant. Thus, the current data set plugged into the Hise et al. (1983) model yields identical results. The inverse relationship between store size and sales is a surprise, at first. However, it appears to be entirely due to multicollinearity among the predictors. Grapentine (1997) notes that multicollinearity can make regression coefficients negative, even when theory suggests a positive relationship. Store size is highly correlated with both stock ($r = 0.74; \text{p-value} = 0.000$) and labor ($r = 0.56; \text{p-value} = 0.000$). Moreover, a regression of store size alone on sales yields a positive, significant standardized beta of 0.51 ($t = 5.87; \text{p-value} = 0.000$).

Table VIII reports results of testing H1, H2 and H3. As expected, inventory increases by the square root of sales, supporting H1. The data also support H2 - merchandise variety exerts a positive effect on inventory levels. However, H3 was not supported. Higher demand uncertainty was not found to increase inventory levels. This may be the result of measuring both safety stock and cycle stock levels together, rather than partitioning them. Demand uncertainty influences safety stock, not cycle stock. However, in a model stock system, safety stock tends to be small relative to cycle stock. Thus, cycle stock may have masked the impact of demand uncertainty.

Table IX presents the stock/service level relationship. In this model, the survey measure of front store inventory is used, since these items are most likely to be advertised and/or sale priced. (Recall the measure of customer service reflects availability of only advertised and sale priced items.) As expected, service deterioration (lack of availability) is negatively related to inventory level. Both linear and exponential models were run for comparison.

Note that the exponential model fits the data better than the linear model, and the exponential model is significant at alpha < 0.05, supporting H4.

Conclusions and implications

Based on a survey of retail chain stores, significant links were found between inventory and each of the following: sales, service level and merchandise variety. Support was found for the theory that
stock increases by the square root of sales. Note that inventory is the dependent variable here; it services demand and is determined by anticipated demand. An alternative perspective models retail inventory as an independent variable, a predictor of sales (Larson and DeMarais, 1999; Urban, 1998). Further research is needed to partition types of retail inventory - cycle, safety and psychic stock - and assess their inter-relationships with consumer demand.

Surprisingly, no relationship was found between demand uncertainty and inventory levels. Theoretically, demand variability induces the retailer to avoid stock-outs by increasing safety stock levels. The lack of significance for demand uncertainty strengthens the need to empirically partition or distinguish between types of inventory. While safety stock services demand under conditions of uncertainty, cycle stock services demand under conditions of certainty. Survey and MIS data combined these two types of inventory, confounding effects on individual inventory types. Again, future research is needed to partition types of stock - and empirically test their determinants.

Clearly, a limitation of the current study is its failure to partition types of stock carried by the retailer. The MIS data included total average stock on hand, without separating the total into cycle stock and safety stock. At a minimum, average order frequency must be known to estimate cycle stock - and safety stock, as total stock minus cycle stock. However, the chain’s regional manager was unable to estimate average order frequency, which varies by item/category of merchandise, by store and by season (for some items). Thus, all four hypotheses were tested using total average stock. Further research is needed to partition stock for hypothesis testing. A good place to start would be with items within a single store. Given estimates of item re-order frequency, along with sales and inventory data, inventory on the shelf could be partitioned into cycle stock and safety stock.

The results demonstrate that fundamental theoretical relationships from the inventory literature seem to occur in the context of a retail chain store operation. Consumer demand and merchandise variety appear to impact retail inventory in a predictable manner. In turn, inventory has a predictable impact on customer service. Hopefully, these results will inspire practitioners to retain data on sales, stock levels, merchandise variety and demand uncertainty. Through analysis of such data, retailers can fine-tune their assortments and inventories to improve store performance.

While these stores were surveyed, the chain had yet to embrace supply chain management (SCM). Little technology was utilized in support of merchandising and inventory management decisions. Nevill et al. (1998) argue that information technology is critical to effective SCM. Retail buying decisions were largely decentralized at the store level. Thus, this (several hundred store) retail chain was not exploiting its volume buying power with suppliers. Since the survey, point-of-sale (POS) scanners have been installed in all stores. Buying decisions are becoming more centralized, and closer relationships are being sought with key suppliers. The stores are collectively moving toward participation in a demand-driven supply chain (Managing Logistics, 1998), i.e. a true pull system. In short, these stores are only beginning to understand and use their power; driven by technology, consumers, and size of the chain (Handfield and Nichols, 1999). Additional research could evaluate the impact of SCM and retail technology on store-level inventory management.

<table>
<thead>
<tr>
<th>Model</th>
<th>Beta</th>
<th>F-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>-0.26</td>
<td>1.43</td>
<td>0.119</td>
</tr>
<tr>
<td>Exponential</td>
<td>-0.05</td>
<td>2.91</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Table IX. The inventory/service level relationship
References


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Appendix. The survey instrument: selected items

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmetics sales ($)</td>
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<td></td>
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<tr>
<td>Pharmacy sales ($)</td>
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<tr>
<td>Front store sales ($)</td>
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<td></td>
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<tr>
<td>Number of cosmetics SKUs</td>
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<td></td>
</tr>
<tr>
<td>Number of front store SKUs</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Front store average inventory ($)</td>
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<td></td>
</tr>
<tr>
<td>Cosmetics average inventory ($)</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Notes: 1 = much less than others; 4 = same as the average; 7 = much more than others

| Table Al. Compare your store with others in the chain, across the following measures: |
|---|---|---|---|---|---|---|---|

| Table All. Please rate the uncertainty your store faces, in terms of the following: |
|---|---|---|---|---|---|---|---|
| Stable volume | Volatile volume |
| Inaccurate projections | Accurate projections |
| Unpredictable | Predictable |

| Table All II. How often do customers comment on the availability of: |
|---|---|---|---|---|---|---|
| New/extended products |
| House brands |
| Items not carried |
| Advertised items |
| “Green” items |
| Sale-priced items |

Notes: 1 = very seldom; 7 = very often