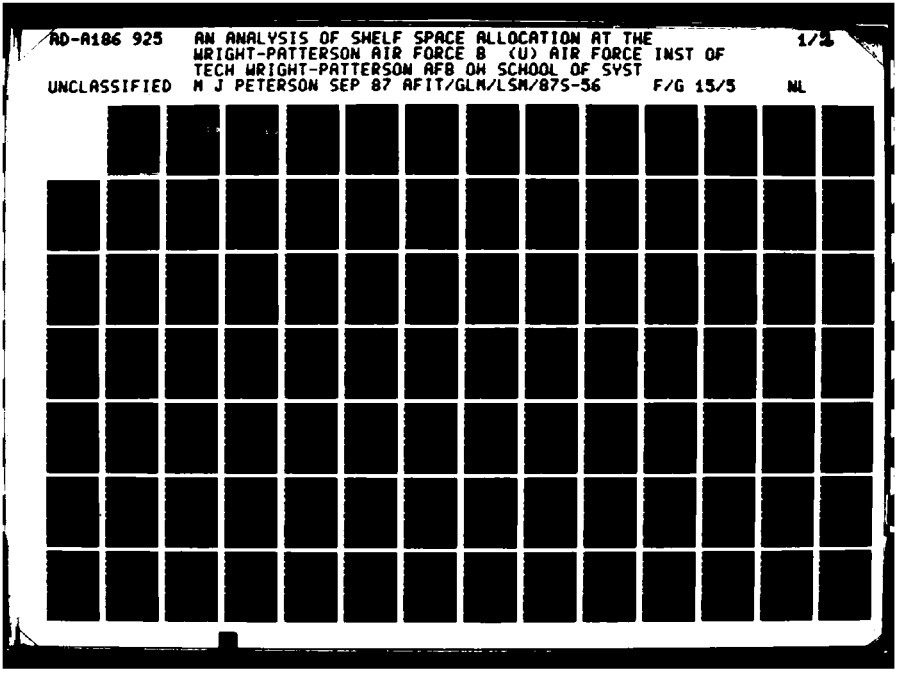
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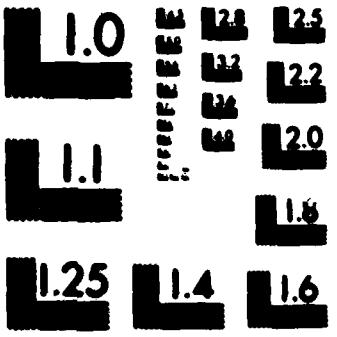


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# AN ANALYSIS OF SHELF SPACE ALLOCATION AT THE WRIGHT-PATTERSON AIR FORCE BASE COMMISSARY

THESIS

Michael J. Peterson
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AFIT/GLM/LSM/87S-56



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AFIT/GLM/LSM/87S-56

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THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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## Abstract

The purpose of this research was to analyze shelf space allocation at the Wright-Patterson Air Force Base Commissary. The commissary had a product in stock goal of 99 percent, which was not being met for all products. The research addressed two different methods of shelf space allocation, within existing constraints of product mix and shelf space available, to limit the out-of-stock situations.

The study was accomplished by an experiment that used an initial data collection period to establish a baseline of sales and stockouts for three product groups. Shelf space was then reallocated for 2 product groups by equalizing the individual product turnover ratios for 1 group, and by stocking to meet 99 percent of demand for the other product group. After a posttest data collection period, comparisons were made using paired *t* tests to compare pre and posttest sales and stockouts for products in all three product groups. A Chi Square test was used to test the relationship between changes in product level stocked, sales and stockouts.

It was concluded that the extra attention paid to the two reallocated product groups led to a reduction in the number of stockouts observed. Equalizing turnover ratios significantly reduced the number of stockouts, while not

appearing to affect the sales levels of individual products. Due to confounding factors, statistical tests were not valid for the reallocation of shelf space to meet 99 percent of demand. The results showed a significant decrease in stockouts, but a cause could not be proved. Keywords: inventory analysis; inventory control; space allocation.

# AN ANALYSIS OF SHELF SPACE ALLOCATION AT THE WRIGHT-PATTERSON AIR FORCE BASE COMMISSARY

## I. Introduction

### Background

The Wright-Patterson Air Force Base Commissary provides retail grocery service to military retirees, active duty military members and their dependents. The commissary's basic mission is to provide a high level of customer service at the lowest possible cost to the customer.

Customer service goals include providing a complete range of commodity groups, offering a choice of brands and sizes for each product type in a commodity group, and providing a 99 percent in-stock rate for all products carried. All grocery products are sold at cost, with a five percent surcharge added at the checkout stand. The surcharge covers losses which occur in the store, with the remainder going to a central Air Force Commissary Service (AFCOMS) fund that provides funds for new construction, renovation and equipment purchase for all Air Force commissaries.

The AFCOMS Headquarters provides a master product list with approximately 14,300 authorized items. Some items must be carried by a commissary, while others are added by local management. Once an item is added, it is seldom removed.

Management assumes that customers expect the item to be available, and, as noted above, AFCOMS has a high customer service commitment. If an item is dropped from the inventory, regional management may require that the item be added back .

Headquarters AFCOMS also provides a master store layout that determines how much linear shelf space is allowed for each commodity group. Local management must allocate shelf space for all products in a commodity group within these limits, with only limited local discretion to make changes allowed. Shelf space is allocated to this large number of products by commodity groups. Space is allocated to individual products based on consumer demand for products and a minimum stock level of one case. These space allocation decisions are based on extensive management experience, management observation and sales volume. These allocations are a critical element of customer service, as product availability has a great impact on customer satisfaction, return business and customer service levels achieved.

The WPAFB Commissary has average monthly sales of $3.6 million. This large sales volume, combined with the more than 12,000 individual products carried, the brand and size selection for each product type, and limited shelf space has led to out-of-stock conditions in excess of the one percent out-of-stock goal. Products that are out-of-stock on the

shelf are not replenished until after store closing, as the commissary uses contractor and vendor stockers that work mainly at night.

Computer product scanning at customer checkout was installed at the Wrightt Patterson AFB Commissary in early 1986. The scanner reads the unique Universal Product Code and queries the computer data base for the item's name and price. The computer stores the number of times it is queried for each product, thus providing a record of unit sales (19). These data are manipulated to generate reports and to aid management in decision making on product mix, inventory and ordering.

The Automated Commissary Operation System, which was installed at WPAFB on 1 March 1987, uses the scanning sales data, a starting inventory level, invoices, orders and receipts to maintain a perpetual inventory. The system is used mainly for product pricing, inventory control, order generation and report generation (11). With more information available from computer generated reports, management anticipates reallocating shelf space, possibly dropping some slow moving products to make space in the warehouse and on the shelves to stock all items to the 99 percent availability rate. The existing software does not address shelf space allocation, but a program is under development (19).

Cox, in a 1964 test of sales responsiveness to changes in shelf space allocation, concluded that increasing shelf space was an inefficient way to attempt to increase sales. The grocer was influenced more by the out-of-stock policies of the store, full case stocking requirements and product assortment policies than trying to increase sales of products in determining shelf space allocation (5:66). James Cairns suggested that the retailer consider himself a seller of retail space to suppliers, and allocate space based on the contribution to gross profit of a unit of shelf space (3:34). The idea of allocating by profit per unit was followed by contribution to profit and opportunity cost concepts of shelf space allocation. These approaches used marginal revenue for analysis, but did not gain popularity due to limited data availability (4:55). More recent theories use scanning data to determine profit generated per cubic foot of shelf space, or some ratio of sales levels to shelf space allocated to value shelf space. These methods are preferable to one dimensional measures such as unit movement, straight dollar sales, gross profit or case movement, as they consider the relationship of demand to the amount of shelf space used (23:173).

A survey in the May 1980 edition of Supermarket Business indicated that managers use a ratio of space to either inventory turns, sales profit or inventory investment

as control measures. Turnover was used as a measure as it directly tied sales to shelf space used (16:56).

A goal of marketing is product time and place utility relevant to a consumer. A stockout situation is a failure of the marketing system that has direct and indirect costs to the seller. Direct costs are the costs of lost sales, while indirect costs include loss of brand loyalty, loss of loyalty to the store and loss of goodwill. Studies indicate consumers facing an out-of-stock condition have a series of choices on substitution or buying elsewhere that usually lead to a loss of sales (27,33).

## Problem Statement

Commissary management is given a fixed amount of shelf space for each commodity group carried in the store. Management must allocate this space to the individual products carried in the commodity group. The customer service goal of providing the widest possible selection of brands and sizes in each commodity group leads to a large number of products being carried. Another customer service goal requires shelf space sufficient to stock the product to meet demand 99 percent of the time. These conflicting goals have led to a situation where the in stock goal is not being met. The problem is complicated by the lack of data necessary to determine what a 99 percent fill rate would be for a product; ACOS provides sales data only on a monthly basis. In short, the problem is the lack of an effective

means to allocate shelf space to meet the conflicting customer service goals of product variety and product availability.

## Justification for Study

Shelf space allocation has been studied for many years by commercial grocers as shelf space allocation has a great impact on sales, customer satisfaction and profit. Various studies have used product movement, profit motive, merchandising goals and logistical goals to as criteria to allocate shelf space. These theories are discussed in greater detail in Chapter II of this research chapter. The studies are not conclusive on the best way to deal with the allocation problem.

Local commissary managers indicated that they planned to reallocate shelf space based on product sales levels, dropping products with the lowest demand in order to meet mandated customer service levels for the remaining products. This approach does not consider the shelf space allocated to each product compared to the sales of each product. In other words, the efficiency of shelf space use is ignored. This approach also assumes that the existing shelf-space allocation is optimal and does not address reallocation of the current space to the current product mix.

The existing data for sales are a monthly summary report for total sales of all products for the month. The report does not track shelf space, daily sales or out-of-

stock conditions on the retail shelves. The information needed to determine stock levels to meet the 99 percent in-stock rate is not available. The management solution of dropping low volume items to free up shelf space for higher volume items does not consider the tradeoffs between service levels and number of products carried. Dropping low volume items assumes that reallocation of existing products can not improve the situation, and implies that existing shelf space allocations for high volume items are correct. More data and analysis are needed to prove or disprove these assumptions. Commissary management recognizes the need for a more scientific allocation of shelf space. This is driving a HQ AFCOMS project to develop a computer program to allocate shelf space. Research in this area could benefit this management effort (19).

Managers that allocate shelf space based on personal experience and historical data may be doing a great job of allocation, but the quality of decisions is unknown and will probably be less than optimal (6:59). Identifying which items should have more space is a difficult task. Presently the criteria used are subjective. While more data can be brought to bear on the problem with ACOS, the impact of reallocation on sales and out-of-stock conditions cannot be measured. Research could lead to better product assortment decisions, and better allocation of shelf space to individual products (6:55).

## Research Objective

The overall research objective was to determine a method for allocating shelf space that will best meet complex and conflicting customer service objectives. The affect that changing the current shelf space allocation for products within a commodity group has on sales and stockout levels for products in the group was also evaluated.

## Research Questions

1. What is the impact on daily unit sales and stockout levels for all products in a commodity group, when the fixed amount of shelf space available is reallocated based on equalizing the product turnover ratios for the products?

2. What is the impact on daily unit sales, stockout levels and products carried when the fixed amount of shelf space available is reallocated based on providing a 99 percent in stock rate for all products carried?

## Scope and Limitations of the Study

This thesis explored the current allocation of shelf space for three selected commodity groups to determine product sales levels, out-of-stock conditions and product turnover. Two alternative methods of allocating shelf space were tested to determine if reallocation affects sales levels and out-of-stock conditions in the commodity groups.

Due to the large number of commodity groups and products carried in each group, a representative sample of

all 85 groups was not undertaken. Three commodity groups selected by local management were studied. Three groups allowed for tests of two alternative allocation techniques and for a control group. Selection by local management ensured that the groups studied had problems requiring reallocation of shelf space (19). It was assumed that the methodology and techniques tested in this research should be applicable to any commodity group.

The remainder of the study is presented in the Literature Review, Analysis and Conclusions Chapters. Major sections of the literature review are: the affects of shelf space on sales, gross profit as a space allocation tool, logistical aspects of space allocation, shelf space and product availability, space allocation based on product demand, product scanning's impact on operations and commissary operations affecting shelf space.

Chapter Three presents the methodology that was used to answer the research questions. Chapter Four provides all relevant data and the results of statistical tests and analysis. Chapter Five uses the results of Chapter Four analysis to answer the research questions, present conclusions and recommend further research. The Appendices include data not specifically required to understand the analysis.

# II. Literature Review

## Background

Managers of supermarkets often find it difficult to allocate shelf space effectively for all products carried. The total number of products carried, the number of new items available, out-of-stock situations, shifts in consumer demand, seasonality of product demand and product promotion all complicate the issue (34:41).

Shelf space is the medium through which suppliers, by way of retailers, reach the ultimate consumer of their products. The retailer desires to earn the greatest profit possible from his fixed amount of shelf space. Any product carried must contribute to profit to be of value to the retailer. The supplier wants a situation where consumer demand compels stocking products even at low margins of profit for the retailer. The supplier can aid the retailer by decreasing package size, by lowering the price to the retailer or by advertising to increase sales levels. These are just some of the tradeoffs involved in a manager's decision making process.

The competition for shelf space comes from many directions. Products in the same product category vie with each other for space, as do whole product categories on a larger scale. Suppliers introduce new products that must displace older products to gain shelf space. Salesmen push

for the best positions and displays for their products at the expense of rivals, and seek to maximize the number of facings allocated to preempt competitors. The manager needs some standardized measure of sales and shelf space to evaluate and compare allocation within and between product categories. With a standard measure the manager can balance the conflicting demands and determine the best use of shelf space (3:34-36,4:55).

This chapter will review methods of shelf space allocation, impacts of shelf space on sales, the effects of product stockout, commissary operating procedures and statistical tests used in the methodology. This review will establish sufficient background to determine a method for allocating shelf space that will best meet complex and conflicting customer service objectives.

## Affects of Shelf Space on Sales

As the new products and variants of existing products offered by manufacturers or producers increased greatly, the selling space available in stores did not increase proportionally. Retail and supermarket store managers manipulated the shelf space allocated to products to try to increase sales levels and profits. The manipulations were mainly trial and error, with a few experiments covering only a few products attempted. The experiments usually tested space elasticity of demand, which is a ratio of change in sales caused by a change in shelf space. The experimenters

hoped to use the data gathered to help make product assortment decisions, store space allocation decisions for product categories or single products, to develop models to test allocation options and to determine store size and location (6:54-55).

The Lee Model proposed that as shelf space for a product was increased, sales would increase at a decreasing rate. Shelf space would be allocated until the marginal returns for all products in a store were equalized. The model did not test well due to the reluctance of retailers to experiment, difficulties in data collection, variations in price or advertising levels and displays that were difficult to maintain for the duration of the test (6:55).

Oesterle feels that "there is a clear relationship between movement and contribution to gross margin", but a disparity between space allocated and gross margin. It is a mistake to decrease space for big selling products to beef up slow moving items. Those slow moving items whose sales can not justify enough space for proper exposure should be cut. The space freed should go to faster moving products or high gross margin items, and not to try to increase sales of slower moving items (30:60).

The idea that shelf space and sales are related or affect one another has both proponents and opponents. A 1980 survey conducted by Supermarket Business found managers using space to inventory turn ratios or space to sales

ratios to determine product shelf space allocations. The survey showed 90.1 percent used some form of computer print out, other than scanning data, to allocate shelf space. Only 18.3 percent had scanning data available, and all used it to track item movement and to weed out slower moving products. The managers used space to inventory turn 52.1 percent of the time, space to departmental sales 47.9 percent of the time and space to departmental profit 35.2 percent of the time (some managers used more than one measure) (16:1+56).

Brown and Tucker determined that three classes of products exist whose sales respond differently to increases in shelf space. Unresponsive products, staples like salt and spices, do not show an increase in sales with increases in shelf space. General use products such as canned vegetables or breakfast foods have sales that increase with increases in shelf space, but with early diminishing returns. Occasional use products or impulse purchase products do not show an increase in sales until the display is large enough to force its attention on the shopper. Once that size is reached, sales increase, but a large amount of space may be required. The research implies that the staples and general use products should receive the minimum space needed to limit stockouts and reduce stocking costs. Occasional use or impulse purchase products should receive larger amounts of shelf space, if available (1:12-13). The

researchers concluded that increasing shelf space leads to an increase in sales. In general, however, the increases are not proportional to the shelf space increases, and all products do not respond in the same manner to additional space. The authors feel in the long run space changes do not affect sales to a great degree (1:12-13).

Cox's research of four product families of staples and impulse items reached the same conclusion. Sales were independent of shelf space, and only one of three impulse items showed a significant change in sales when shelf space was increased (6:56).

Pauli and Hoecker showed that space changes had a greater effect on sales in many branded fruits and vegetables than in product families with fewer brands. Products that were faster sellers showed a greater change in sales when shelf space was changed than did slower selling products (6:56).

Frank and Massey developed a model to estimate how shelf space policy affects sales of different brands and different size containers. They felt that there was little research in this area and that managers seldom significantly altered the number of rows allocated to a product regardless of the number of brands or sizes carried. The model sought to determine the affect on sales of changing the number of facings, the height of the product from the floor and the interaction of the two variables. They hoped to determine

if shelf space should be modified to try to increase sales, or adjusted in relation to past sales. Data were collected in different departments and in stores with differing sales volumes. Each data set was evaluated separately. The results showed that interaction of the change in number of facings with the change in shelf height did not explain the relationship of the variables to sales more than the main effects of the two variables considered independently. The report was based only on the main effects considered separately. The results varied as the sales volume of the stores studied varied. The conclusion reached by the researchers was that adding facings in a high volume store, within the range of 5-10 facings, added to sales. In high volume stores increasing shelf facings had a greater effect on sales than in low volume stores, regardless of container size. Overall, varying shelf level has a very limited impact on sales (9:59-64).

Several studies on the impact of shelf level on sales give conflicting results. This supports the previous model that indicates results vary in experiments based on store location and store sales volume. The Colonial study showed that waist level shelves had sales 74 percent of eye level shelves, and that the figure for floor level shelves was 57 percent of eye level. Heavy products on high shelves showed fewer sales than heavy products on low shelves.

Curran also developed a model to attempt to explain space elasticity as a function of different product variables. The research did not identify variations or differences in elasticity. It did conclude that a slight positive relationship existed between space and sales, but not for all products. A shelf space change of 40 percent resulted in an 8 percent change in sales in the same direction. These small relationships and the difficulty in determining elasticity limit the effectiveness of this method to increase profit by increasing sales. The author concluded that minimization of restock costs and avoidance of stockouts were more important than merchandising in determining shelf space allocation (7:406-412).

The overall conclusion reached by Curran in a review of many of these studies was that a small positive relationship existed between shelf space and unit sales that was uneven across product categories or stores. Generally, manufacturers' brands were not affected as much as private brands by changes in shelf space. The findings, taken together, were considered inconclusive, and other variables such as display, location, price and promotion had a greater affect on sales than shelf space (6:56-57).

Gross Profit as a Space Allocation Tool

Gross margin or marginal gross profit was used by several researchers to allocate shelf space. Cairns, in his 1963 article in Journal of Retailing, advocated allocating

shelf space to maximize gross profit. He assumed selling space was fixed and of equal value. He felt retailers should rank the items carried by contribution to gross profit, then stock items on the top of the list and drop items on the bottom if profit would be improved by doing so. New products were assigned an estimated profit and added to the list. The movement of products on the list would continue until the marginal gross profit for all products was equal (2:41-52).

Cairns qualified this theory by noting that interdependence of demand was ignored, and exceptions were made to ensure a sufficient assortment of products was available to attract customers. It did not consider the problem of lumpy additions. A lumpy addition occurs when the retailer needs to add a certain number of units to equalize marginal profit, but must add more than desired as the added facing holds more units than are required. The same problem occurs with restocking when less than a full case is required to fill a shelf, and restocking policy calls only for full case restocking (2:41-52).

## Logistical Aspects of Space Allocation

Shelf space is allocated by some managers to meet logistical or operations needs, with sales level or profit not considered. Some considerations that affect space allocation are labor costs, assortment policies dictated by a higher level of authority, case pack or customer service

level desired. Wickern discusses the relationship between labor costs and shelf space in an article published in the Spring 1966 Journal of Retailing. He reasons that a decrease in shelf space leads to an increased cost in labor to restock the shelves more often. If a product has enough shelf space to hold a weeks demand, the cost of shelf space is high and labor costs are lower. This requires six or seven times the shelf space of only stocking a days supply, but saves the cost of frequent restocking (35:36-46).

All stores have different situations with sales levels, shelf space available and labor costs. As such, only general rules of shelf space allocation can apply if shelf space is allocated but not valued. The general decision rules are (1) that some inefficient or low selling items must be carried to draw customers, (2) an assortment of product types is required to provide customers a choice of brands or sizes and (3) that stock levels be sufficient to preclude restocking during busy store times (35:36-46).

Shelf space can be valued by gross profit per linear, square or cubic foot; return on investment, profit per unit or profit per commodity group. Using the same data and these different valuation techniques, the allocation of shelf space decisions differ. Management can get many different allocations, depending on the way the data are defined and the valuation method used. Due to the differing results that are possible, the author prefers general

decision rules unless detailed studies are performed to apply valuation techniques (35:36-46+63).

Curran, in an article in the Journal of Marketing, provides a synopsis of thought on shelf space allocation. A consensus exists that managers need to satisfy the minimum operational and logistical constraints of stocking, such as labor costs and stockout , before considering merchandising as an allocation measure. Profit and product movement determine the space allocation within the constraints of space availability and logistical considerations. Unit size, case pack, delivery frequency and the physical layout of the shelf space determine the minimum and maximum limits of allocation. Levels of stock need to vary for products based on the level of consumer brand loyalty, promotion efforts and the availability of substitute products. Variable in-stock service levels, which set higher service levels for products with strong customer brand loyalty or lower levels for substitutable products, should be used (8:221-222).

Curran states an Electronic Data Processing system greatly simplifies this procedure, if it allows user input and changes. Allocation of shelf space should be to products that will have the greatest improvement in rate of return for the store, within the operational and logistical constraints. The improvement in return is a function of profit margin and space elasticity for the individual

products, a figure that is difficult to calculate. The profit calculation is relatively simple using Direct Product Profitability (DPP), which is a technique that uses a unit measure of contribution to profit and overhead of a product in a square foot of shelf space. It uses standard costs of doing business to determine breakeven points and pricing policy. Using the information, distributors can allocate space to maximize the return on investment. This program has not been implemented due to problems in gathering data, and the cost associated with implementing the program (8:221-222).

COSMOS, a computerized shelf space allocation program, uses DPP as a decision tool. Profit improvements realized by use of COSMOS were probably caused by reductions of stockouts and release of excess space to new product lines. The program assumes all products have the same space elasticity. The program does not consider increasing space as a way to increase sales, as the elasticities are equal for all products. In spite of the limitations of DPP, Curran prefers this type of measure to allocate shelf space. The space allocation is made by equalizing the profit per square foot of the display area within a product category (8:221-222).

Another computerized shelf space allocation program, Store Labor and Inventory Management, was developed to allocate shelf space to minimize the overall stocking

expense of a retail operation. The program allocates shelf space to permit shelf restock upon delivery, with no product stock held in a local warehouse. Reserve space is allocated on the display shelves to ensure the display has a good appearance when the restock point arrives. The last requirement is that the restock level be at least one case. This system was never tested due to the amount of shelf space required, and reliance on timely delivery (6:58).

A test performed by Cox in 1964, used an ANOVA procedure to develop a model to determine the relationship between shelf space and product sales. The test showed that variables other than shelf space affected sales. This author also concluded that increasing shelf space was an inefficient way to increase sales. Retailers were more influenced by out of stock policies, full case stocking and product assortment guidelines than increasing sales in allocating shelf space (5:66).

Shelf Space and Product Availability

Product availability is a major component of customer service that often does not receive management attention. A basic assumption of marketing is that the product is available at a time and place relevant to the buyer. Research by Schary and Christopher shows that customer perceptions when faced with a product out-of-stock situation are not universal, but that the reaction can influence the customers' perception of the store. A

stockout study in 1968 showed an 11 percent decrease in gross sales when consumers were faced with an out-of-stock situation (27:59-69).

The immediate impacts of a stockout to a retailer are the direct loss of revenue, possible loss of brand loyalty or a loss of power to attract customers to the store. The impact varies in each situation, as consumer behavior varies based on the degree of brand loyalty, store loyalty or the level of desire for a specific product brand or size. The consumer's options include substitution, postponement of the purchase, no purchase or purchase in another store. Even occasional stockouts can weaken brand or store loyalty, while repeat stockouts could lead to substitution for the product or exclusion of the store. Stockouts, in this research, did not show any overall beneficial outcomes for the retailer (27:59-69).

Walter and Grabner developed a stockout cost model, as few space optimization models included the cost of stockouts as a variable. Other variables usually not considered included loss of goodwill, item substitution and uncertainty. Their model starts with a consumer facing a stockout situation. The consumer can decide not to substitute for the product and either return to the same store later, or go elsewhere to find the product. If the consumer decides to substitute, it can be for a different size of the same product or for a different brand. In

either case the price or profit associated with the substituted product can be higher, lower or the same as the originally desired product. The only other alternative for the consumer is to special order the product. Each alternative has a computable cost to the retailer. The researchers used a questionnaire given to liquor store patrons in Onio to determine what percent of consumers would take which action. Given the action and cost of each action it was determined that a stockout cost the store $1.26, or 24.2 percent of the average cost of a customer transaction. The losses were caused by loss of sales and customers switching to less expensive products (33:56-58).

Lambert and Stock's view of stockout is directly related to customer service levels. Customer service levels help determine if customers remain customers, but tne definition of an appropriate customer service level depends on what a customer expects or will accept, and tne cost the supplier is willing to bear. A major facet of customer service is time and place utility of a product for a customer. The cost of lost sales due to stockouts is difficult to determine for different service levels. A tradeoff between cost of loss sales and inventory cost to maintain a certain customer service level is required. The model used in the text is Walter and Grabner's model discussed previously (31:57,66,67).

The customer service level provided by an organization is a management decision based on variables including customer relations, customer desires, ability to meet a specific level of service and the cost involved. As customer service levels approach a 100 percent capability to meet customer demands from inventory, inventory levels increase disproportionately to the increase in service level. A customer service level of 84.1 percent requires that average demand plus one standard deviation of demand be available. A level of 94.5 percent requires 1.8 standard deviations, 98.9 percent requires 2.3 standard deviations while 99.9 percent requires 3.0 standard deviations of demand. The increase in inventory levels required to meet the higher customer service levels raises the costs associated with carrying the inventory. These costs include increased investment in inventory, increased taxes, storage obsolescence, damage, shrinkage and labor (31:377).

Lambert and Stock recommend that all products not be treated alike, but that ABC analysis be used to determine proper customer service and inventory levels for each customer and product. A rule of thumb is that 20 percent of the products or customers account for 80 percent of the sales and profit. ABC analysis ranks products by sales or contribution to profit. It also ranks customers by the same method. The two rankings are used to determine the customer service level for each customer and the stock level for each

product. The process emphasizes taking care of the 20 percent that contribute the most to the companies sales and profits. Symptoms of poor inventory management that indicate that ABC analysis could be appropriate are an increase in the dollar value of inventory without improving customer service or stockout levels, periodic lack of storage space and a wide variation in inventory turnover among major inventory items (31:415-421).

Progressive Grocer equates stockouts to customer dissatisfaction. Stockouts also cause operational problems, in that they disrupt established stocking patterns. The space allotted to a product becomes uncertain, and the uncertainty leads to problems in restocking. Other products may take the space, and the stocker may not be able to determine the appropriate stock level. There is also a cost associated with stockouts that the retailer must bear. An actual example is a stockout of 32 ounce mayonnaise that led to a 13 percent increase in sales of 16 ounce mayonnaise. The overall cost was an overall decrease in dollar sales of 26 percent for mayonnaise as a product group. A stockout of a one of a kind salad dressing led to no offsetting purchases, resulting in a total loss of sales to the grocer (34:42).

Herron writes that much research has been done on inventory levels to meet a specified order fill rate from inventory, which equates to customer service level. Less

research has been done on what is an appropriate service level. The service level decisions are made by management, but the decisions require complex tradeoffs that management often does not have the information to make. Most United States retailers turn their inventories 4 to 6 times a year. Supermarkets and commissaries turn their inventories much more rapidly, as some products are perishable, while others are seasonal. Cost reductions in inventory using techniques such as Just in Time or Material Resource Planning save by reducing inventory levels and reducing stockouts, given a required customer service level (13:96-98).

The probability of a stockout depends on the stock level held by the retailer. The stock held determines the cost of inventory; including the working capital tied up, deterioration, obsolescence, labor costs, storage costs, insurance and inventory control costs. Herron states that these costs run an average of 20 percent of the value of the products held (13:98-102). Lambert and Stock state that inventory carrying costs should be calculated for each product, as they vary for each product. The figures should be updated annually as better data are available (31:254). Tradeoffs involved are a high customer service level at a higher cost, or a lower service level with the increased cost of stockouts (13:98-102).

Herron states that existing models to determine inventory levels use single item optimization rules such as

Economic Order Quantity to determine order quantity or stock level. Management should be more interested in an overall aggregate service level which would allow tradeoffs of costs in transportation, purchase and storage. Aggregate inventory management allows a lower service level for high unit cost items or items with erratic demand, and allows a higher service level for lower cost items with a more predictable demand. The program allows an aggregate level of demand to be met at overall minimum cost. The customer service level determined by management is met for the inventory as a whole, while individual items will have a level determined to minimize inventory costs. Models using equal turnover ratios, equal service levels or constant level ordering cost 10 to 50 percent more than the aggregate service level program. The author states that establishing customer service levels based upon the relationship of costs and profit eliminates the arbitrary selection of customer service levels without knowing the impact on customer service levels on profit and costs (13:96-114).

Space Allocation Based on Product Demand

Another school of space management thought proposes space to inventory turn or space to sales ratios to identify existing product space allocation strengths and weaknesses. The advent of scanning data and other inventory management or control methods allow more scientific analysis of product demand data. Item movement reports can provide information

to better manage shelf space. A 1980 article in Supermarket Business showed that velocity reports are used to identify weak products, to better manage expensive products and to identify categories of products whose sales have peaked. Information from these reports have led managers to stock private brands at the expense of national brands and to provide more shelf space to non-food items at the expense of food items. Managers indicate that shelf space adjustments, or resets, based on customer demand leads to stocking the items customers want to see and also increases profit. An average non-food product category has its shelf space reallocated or reset 2.8 times per year, canned goods 3.1 times per year, dry grocery products 2.7 times per year, dairy products 3.8 times per year and frozen foods 3.5 times per year. Dairy and frozen foods are reset more often due to the high number of new products, the refrigeration requirement and the high value of items stocked in those product categories (16:56-60).

Rauch states that the shelf space allocated to products can increase unit sales, profit and inventory turnover ratios. He believes that all product categories should be merchandised, and shelf space allocated, according to the product's local market share. The allocation by sales should extend all the way through a product category, including flavor, size or package type for each product.

This allocation should reduce product stockouts and make the products easier to find on the shelves (25:78-79).

A common methodology to perform this reallocation is to compile historical sales data for product categories of interest. Using these data, shelf space is allocated to meet the expected sales . After the reallocation, data are again collected and analyzed. At that time reallocation can again occur, followed by another period of data collection.

Rauch proposes a Vertibrand stocking policy where shelves are stocked vertically by brand and horizontally by package type. The display should hold a weeks' demand for all products. This allows all brands to sell down at the same rate, which reduces the stockouts and allows restocking at one time for the whole product category. Planograms are used to match displays with actual sales, thus allowing shelf space to be allocated based on demand for the product. This approach must be done on a store by store basis, due to differences in demand between locations and even stores in the same area. An additional benefit is less obsolescence, as all products turn at the same rate (25:78-79). In this situation demand determines shelf space needed. The need for shelf space may not match the desired Vertibrand layout for all products. Stocking a weeks demand for all products limits the number of products that can be stocked. It may be more efficient to stock to a different level, depending on the products carried and store volume. The main emphasis

is to limit the cost of restocking the shelves without considering any of the other variables that come into play.

The Dillon Company performed a major shelf space allocation study involving 59 of their stores. The study involved planning and executing a shelf by shelf reset of all products in all stores. The location of products and shelf space allocated were both changed. Management stated "Our golden rule is profit determines position and volume determines space." The study used a gross profit per item measure to determine display position, and sales levels to determine shelf space allocated for each product. Slower selling items were deleted if their shelf space could be better used by other products. Private labels were pushed at the expense of national brands. Good sellers were placed at the end of each section, and others were interspersed to attract customer attention to all products around them. High volume, low profit items received more space, but not in the best positions. As new products were added the slowest moving product with more than one size available was eliminated to provide shelf space for the new product. The study indicated that the overall sales volume per square foot of shelf space increased, stockouts were reduced or eliminated and profit increased. The study also revealed that 80 percent of all products carried sold less than a single case per week. This is significant because it suggests that 20 percent of the items carried generated a

larger percent of sales. A restock policy of a minimum of a single case, in this situation, means 80 percent of the items will have over a week's worth of product on the shelf (28:53-56).

Oesterle also advocates allocating space based on product movement and gross dollar margin returns. He believes in cutting the number of products carried, showing the remaining products well and playing up the high volume products. While "there is a clear relation between movement and and contribution to gross margin," there is a disparity between space and gross margin or movement. The more a product sells, the higher the contribution to profit. An example from one store shows that the top four dairy products provide 85 percent of the product category sales, 82 percent of profit but have only 70.5 percent of the available display space. The manager reduced the space for his best sellers and gave it to the slower sellers to beef up their sales. Oesterle believes space should be allocated based on demand and profit, and that high demand item placement can help move slower selling items (30:60).

Kellogg uses a product movement program based on the sales history of each product to provide store managers a tailored stocking plan for all cereals carried. The stock level on the shelf is set to avoid stockout situations. Kellogg's Director of Marketing Research states that "shelf space according to sales is the best thing to come down the

pike. We (Kellogg) still don't have the space we deserve" (15:100). General Mills, General Foods and Quaker do not object to the system as they feel they get their fair share of space. A major problem with the program, noted by consumer protection groups and producers, is that the program creates a barrier to new cereal product entry to stores utilizing it (15:2,100).

Product Scanning's Impact on Operations

Scanning of Universal Product Codes (UPC) at checkout provides benefits greater than increasing the speed and accuracy of the cashier in totaling customer bills. The data collected by scanning can be used by management in many other ways. Measurable benefits include decreased labor costs at checkout, and elimination of marking the price on each item as it is placed on the shelf. The scanning system must be augmented with software and hardware to process the raw data into a usable format. Increased control of inventory is possible as tracking sales as they occur allows maintenance of an accurate perpetual inventory. A perpetual inventory allows better control of inventory levels, ordering and identifies product shrinkage. Additional benefits include item by item data on product performance that can be used in merchandising or marketing decisions. Data available include product movement, price control, current sales, product category sales and historical data on product movement. This availability lends itself to product

experimentation. Many managers use the data mainly for product movement, for identifying slow moving products, for stockout reports and for tracking new product performance (24:38-40).

Many managers use exception reports that highlight variations from the norm to determine the product assortment carried in the store. More sophisticated applications that handle shelf space management or special merchandising are limited. Examples are COSMOS and SLIM, which were discussed earlier. Many existing report formats use only a single measure or dimension to provide a best or worst measure of performance. Examples of single dimension reports are unit movement, dollar sales, gross profit or case movement, while a few use one of these measures per cubic or square foot of shelf space.

O'Neil prefers the ScanLab program, which uses sales levels and cubic foot measures of shelf space to manage item shelf space. It uses unit movement, gross profit per item, unit shelf space, number of weeks movement available on the shelf and return on investment as criteria to judge best and worst performers. The report includes the best and worst overall performer in each product category, the item with highest movement and all items with zero movement. These multiple measures provide the manager with information to make tradeoffs in determining product assortment and shelf space allocation (23:173).

## Commissary Operations Affecting Shelf Space

The Wright-Patterson Air Force Base Commissary uses product scanning at checkout to determine customer payment, and to provide sales data to the Automated Commissary Operating System (ACOS). The ACOS system is provided to the commissary by AFCOMS, and is used mainly to generate reports. ACOS is a hardware and software package that uses input from scanning, product receipt reports from the warehouse and manual adjustments to track inventory levels and generate management reports. The main use of ACOS is inventory tracking. Given a starting inventory level, ACOS maintains a perpetual inventory by subtracting sales, adding deliveries and subtracting adjustments for spoilage or returns. The inventory data are used to generate price changes, as the commissary sells all products at cost. The system determines when a price change is necessary based on movement and the price paid for items. This is necessary as a single product in the warehouse could be from, for example, three separate deliveries with three separate costs. The system generates invoices and receipts, tracks deliveries and order status and tracks vendor performance in meeting delivery schedule and percent of order filled. This is important as unfilled orders are canceled and a new order is generated to make up the shortfall (11,19).

The ACOS allows use of hand held order input devices using barcode readers to scan UPCs from either a shelf label

or from a product. The shelf labels are printed by the ACOS, and they contain the UPC, price, product name, the barcode for the UPC and a space for the number of facings of shelf space allocated. If a product requires restocking, the order writer scans the product or label and enters the number of cases required to fill the shelf.

ACOS also generates a Commissary Analysis Management Information (CAMI) report. The report is produced at the end of each month. It lists all products carried by product category. The products are listed within product category by sales volume. Each product has information on price, quantity sold, total value of product sold, percent of total product category sales and average daily sales. Other information provided includes total units sold in a category, total value of all units sold in the product category, percent of total department sales and average price of a unit. The report is used to determine product movement and to identify candidates to be dropped (19).

Commissary management must operate within guidelines established by two higher levels of management. The store layout is standard for all commissaries. The amount of shelf space authorized for each product category is also directed. A master product list provides a list of approximately 14,000 items management can choose to carry. A certain number of these items must be stocked, while local management has discretion on others. Some local products

are allowed, along with variation allowed for seasonal items peculiar to the area. For example, the master list contains 27 types of peanut butter, and the commissary now carries 24 of them. The store layout allows 13 feet of shelf space for peanut butter while the commissary has 6 feet of shelf space allocated (32).

The commissary customer service policy calls for a 99 percent in stock rate for all products, except for 200 products which require a 100 percent in stock rate. Setting a required stock level for each product is a mathematical problem involving the mean and standard deviation of daily sales and a Z or T critical value for 99 percent (10:214-218). If shelf space is available for this or for a greater stock level, there is no problem. Selection of products to be dropped or kept if space is not available is a management decision based on demand levels, number of products carried, price, number of brands and sizes carried and store policy on minimum selection availability (5,7,35).

Commercial grocers also operate with restrictions or guidance from higher levels of management authority. A survey in Progressive Grocer showed that 35.6 percent of stores were stocked exclusively from a product list from higher management. In 45.2 percent of the stores headquarters provided a list which local managers picked from, while an additional 16.4 percent could buy locally outside the list. Only 2.6 percent had no control from

above. In store layout 32 percent used a standard store layout, 65 percent followed a standard layout with minor changes authorized and 3 percent had no controls imposed (14:164-165).

Now that the literature review has provided a background to understand shelf allocation problems, the stage is set to move onto the methodology of this research. Most of the studies and authors presented in this chapter studied commercial shelf space allocations where the main emphasis was to maximize profit, either by reducing costs or stocking products based on demand and profit generated. As stated previously, the commissary's main goal is to provide a service to military members, not to make a profit on sales. The commissary's emphasis on customer service instead of profit leads this research to look at customer service levels as a means to allocate shelf space. The background section of Chapter III gives a description of the experiment, and a description the allocation of shelf space to meet customer service levels.

# III. Methodology

## Experiment

The research will be performed as a two phase experiment that will investigate the effects of changing shelf space allocations on sales levels, stockout levels and customer service levels. The first phase will be a data gathering phase used to establish a baseline of daily sales distributions, product stockout levels, existing space allocation, product turnover ratios and product availability levels for the three selected commodity groups. Data on product attributes, such as case size etc., that affect how much shelf space a product uses will also be gathered.

Once enough data are available to determine sales distributions, the shelf space allocation will be modified based on differing goals of customer service. One reallocation will be based on stocking all products to a 99 percent availability rate. In this situation shelf space will be provided to products to allow stock levels equal to the mean of daily sales plus 2.326 times the standard deviation of sales. If there is not enough shelf space available to stock all products in the commodity group to this level, management will decide which products to drop.

The other reallocation will be based on stocking all products to an equal turnover or availability rate that will be determined by demand for the products and total space

available. In this case no products will be dropped. Shelf space will be allocated to each product until the ratio of daily average sales to the amount of product available on the shelf is approximately equal for all products. Case size, product size and varying depth of shelving will cause variation in the ratios. The turnover ratios may cause the product availability rate to be lower than the 99 percent goal, but it should be nearly equal for all products in the commodity group (20:214-218).

After reallocation, the test phase will begin. In this second part of the experiment, data on sales and out-of-stock conditions will again be gathered. Comparison of the differences in sales, stockouts, turnover ratios and product availability rates between the two periods will give an indication of the affects of the shelf space reallocation (9:65).

A paired TTest, using pretest and post-test data, will be used to determine if differences in sales and stockout levels between the two time periods are statistically significant. The MEANS Procedure in SAS is appropriate for paired comparisons. MEANS uses Students T value to test the null hypothesis that the mean of the differences of the paired data for the samples is zero. The alternative hypothesis is that the mean of the differences of the paired comparisons is not equal to zero. It also gives the probability of getting an absolute value of t greater than

the value of Students T. The test will be performed with an alpha level of .05 (25:961-5). The effectiveness of reallocation will be determined based on whether the test shows a significant change in sales and stockout levels for the commodity groups that can be associated with change in facings made during the reallocation.

## Population

The population under study is defined as the daily sales of products in the selected commodity groups. The commodity groups picked by local commissary management were liquid salad dressing, peanut butter and cake mixes (19).

## Sample

The daily sales are assumed to be independent and random as the arrival of customers making purchases are random and independent. Two sample time periods will be used with a break between them for data analysis, experiment formulation and product shelf space reallocation. Time periods will be selected to limit seasonal variations such as weather, vacation periods and seasonal demand for products. The time period will be long enough to encompass the variations in the commissary sales caused by the twice monthly military paydays.

The number of samples for the data gathering phase and the test phase will be equal to limit variation. Twenty-four to thirty days will be sampled to cover the business

cycle aspect, and provide enough data to determine a sales distribution (22:496-98).

Data Availability

Sales data are accumulated by the product scanning process at the checkout stands, and are available from August 1986 to the present. This data base is unusable for this research, however, as it includes data from both the main commissary and the Wee Serve, a small separate commissary operation. In addition, the data are available only for weekly or monthly sales periods, depending on when reports were printed. Stockout levels on the shelves, daily stock levels on the shelves, changes in space allocation, special displays and promotional information are not available (19).

All required data will be collected by the researcher and commissary staff. Data will be gathered by utilizing the scanning system generated sales reports, the daily replenishment stocking printouts and by daily physical inventory.

Variables

Daily Sales. These data will be collected by the Universal Product Code scanners at customer checkout. The ACOS keeps a running total of cumulative sales for all products on a monthly basis. The Commissary Administrative

Office will extract the required information from the data base daily, and print it in a report format.

Manual manipulation of the cumulative data will be required to eliminate Wee Serve sales data on the limited number of items in the commodity groups carried in both the main store and the Wee Serve, and to determine daily sales figures. This is necessary as the ACOS does not differentiate between sales made in the Wee Serve or the main commissary. The commissary staff or researcher will monitor daily sales in the Wee Serve by taking the stock level after store closing. Adding items stocked after closing gives the stock level at store opening. The replenishment stock records are assumed to be accurate, as they are the basis for determining payment due to the contract stocker under a service contract. The stock level at the close of the next business day, minus the stock level at the start of the day gives the daily sales for the Wee Serve.

Daily sales in the main commissary will be calculated by subtracting the prior days cumulative sales from the current days cumulative sales. The Wee Serve daily sales will then be subtracted from this total. As a back-up to the cumulative sales reports, the researcher will make random inventories of product on the shelf after store closing. This, combined with the replenishment stock records, will provide a means of verifying scanning data or

possibly recovering data if report generation fails. Daily unit sales will be grouped by individual products and by total unit sales in the commodity group. The daily sales data will be manipulated by the SAS Means Procedure to determine the mean and standard deviation of daily sales and turnover ratios.

The SAS UNIVARIATE Procedure will be used to verify that the sales data come from a normal distribution. The assumption of normalcy is critical for further parametric statistical tests and procedures. The SAS UNIVARIATE Procedure provides several tests for normalcy that must be considered as a whole to determine normalcy. UNIVARIATE provides a test statistic for the null hypothesis that the input data are from a normal distribution. The test statistic for sample sizes less than 51 is the Shapiro-Wilk statistic, W. W has a value between one and zero, with normalcy indicated by values close to one. It provides a stem-and-leaf plot and a normal plot that will be visually interpreted. Criteria for normalcy will be a W of .80 or greater, with the shape of the plot and the closeness of the values of the mean, median and mode also considered (26:1183-90,32).

Daily Stockout Levels. Daily stockout levels will be collected by the researcher after commissary closing. A product will either be out-of-stock on the shelf, out-of-stock in inventory or in stock. Products out-of-stock in

inventory will show no data available for that day, if there was no product on the shelf at the start of business. The experiment assumes products are replenished nightly when sales have depleted the stock level by at least one case. Including zero sales for days when the product is not available would skew the distribution of sales, and thus the mean and standard deviation of daily sales.

The daily stock replenishment records will show which products were not restocked due to product nonavailability in the warehouse inventory. Another indication of this situation would be two consecutive stockout conditions for the same product with no change in cumulative sales. Products showing a stockout condition will be examined to determine the stock level at store opening. This is necessary to determine if the stockout is caused by inadequate shelf space allocation or inadequate stocking. The MEANS Procedure will be used to determine if significant differences in stockout levels occurred between the two time periods.

Shelf Space. Shelf space is the total linear length and depth of shelf space allocated for each commodity group. The total shelf space allocated for each commodity group is a given that local management cannot vary. Shelf space allocated to individual products determines how much of each product can be stocked, and this cannot change during the first phase or after the reallocation is made for the test phase.

Product Attributes. These data include width of each product, which determines how much room a facing of a product on the shelf requires; the depth of the product, to determine the number of items that can fit behind one facing; and the current facing allocation. The number of items per case will determine the minimum stock level allowed, and thus the number of facings required for a product. One case is the minimum restock level acceptable to commissary management, as it is too labor intensive to pull partial cases or return partial cases to the warehouse. Changes in prices, specials or additional in-store promotions, including additional display space, that could affect sales levels will be monitored.

Store Information. Daily total sales data; broken into sales for the grocery, meat and produce departments, are available. These figures will be used as part of the control measures to determine if differences exist between the two time periods in the experiment. The SAS Procedure MEANS will be used to compare the two time periods to determine if significant differences exist. If significant differences do not exist, it is an indication that differences in sales or stockouts in the individual product groups were not caused by differences in overall store sales.

Reallocation Techniques

Shelf space for the individual products in the two commodity groups will be reallocated based on satisfying different levels of customer demand. The first commodity group will be stocked to allow all products on the shelf to meet customer demand 99 percent of the time. The second commodity group's shelf space will be reallocated to stock all products to the same product turnover ratio. This turnover ratio will depend on customer demand for each product and total space available. The third commodity group, a control group, will not have its shelf space reallocated. The matching of commodity groups with reallocation techniques will be done randomly.

Once the distribution of daily sales is determined, the allocation of shelf space to meet the 99 percent in stock service goal is a mathematical problem. The mean of daily sales plus 2.326 times the standard deviation of daily sales gives the amount of product required to meet the 99 percent product availability goal (10:214). This figure, divided by the number of units of product in a single facing, gives the number of facings required to stock to this level. The number of facings must be rounded up to an integer value, as a facing can contain only one product type. Rounding up could actually provide more space for a product than is required to meet the goal.

The second reallocation assumes no products will be dropped, and that the available space will be allocated equally among the products based on turnover ratio. Turnover is defined as product sold divided by product available. Instead of using a set number of standard deviations to achieve a set level of service, this procedure allocates shelf space to each product until the ratios of average sales to product available are approximately equal.

A statistical test to compare the average turnover ratios for each product in a product group with all the other products in the product group is needed. A multiple comparison procedure is needed as more than three product turnover ratio comparisons will be made. The multiple comparison procedure looks at all possible pairwise comparisons of turnover ratios, while applying the desired confidence coefficient to the whole family of comparisons, and not just to a single test. The Tukey Method of Multiple Comparisons is appropriate, as the factor levels for sample sizes will be equal, and the method guarantees a minimum confidence coefficient of .05. The actual confidence coefficient could be smaller if not all pairwise comparisons are used (22:473-6).

## Data Assumptions and Limitations

It will be assumed that the scanning data, remote operations sales data, and replenishment reports are

accurate. The other main assumptions are that the daily sales are independent and random. The main limitation is time to collect data.

The experiment will use product groups selected by commissary management. The commodity groups will be known or suspected to have an inappropriate shelf space allocation. This increases the probability that significant differences will be found, and that reallocation will help the situation. This should not be taken to mean that all commodity groups have the same problems.

## Method of Analysis

Statistical analysis will be accomplished using the SAS Statistical Package. The system provides tools for analysis including data management, programming capability, report formatting, statistical analysis and file handling (13:XV). All tests will be run with an alpha of .05 unless otherwise stated.

## Research Questions

Research Question 1. What is the impact on daily sales and stockout levels for all products in a commodity group, when the fixed amount of shelf space available is reallocated based on equalizing the products' turnover ratios?

To answer this question, the product group's pre and post-test daily sales and average daily stockout levels will

be compared. The daily grocery department sales will be compared and used as a baseline for comparison for the experimental product groups daily sales. The SAS MEANS Procedure will be used to compare the data from the two time periods, and determine if a difference in means of stockouts and sales occurred. If there is no significant difference in the control group's sales and stockouts, and the grocery department's sales, it is an indication that little variance in operations occurred between the time periods. The control group will be compared to the reallocated groups to determine if sales and stockout levels differed between the groups. If differences are evident they will be considered in the analysis.

The experimental commodity group will receive the MEANS test to determine if significant differences between the two time periods' average daily sales of individual products and average daily product stockouts for the commodity group as a whole exist. If the control group sales and stockout situation and the overall grocery department sales show no significant changes in sales, any changes in product sales or stockout could be related to the change in shelf space allocation. The criteria to judge the affect of reallocation are whether the test period showed significant change in stockouts or sales levels for individual products, or for the commodity group as a whole.

If the directions of change for the three variables cannot be readily interpreted, a contingency table analysis will be used to determine the independence of the direction of change for the variables. For example, if sales, stockouts and change in number of facings all show a decrease, it will be hard to determine if the changes are independent or dependent. A contingency table uses a Chi-Square statistic to compare the actual occurrence of events with the expected occurrence of events. The null hypothesis is that the occurrences are independent, and the alternative hypothesis is that they are dependent. Dependency implies a cause and affect relationship (20:799).

Reallocation should equalize the product turnover ratios for all products. An additional Tukey Test will be performed on the second time period data. A product by product comparison of the number of significantly different turnover ratios will indicate if the reallocation achieved the goal of equalizing turnover ratios. The MEANS Procedure paired TTest will compare the number of significantly different turnover ratios for each product for the pre and posttest time periods to determine if the number of significant differences changed.

Research Question 2. What is the impact on daily unit sales, stockout levels and product carried, when the fixed amount of shelf space available is reallocated based on providing a 99 percent in stock rate for all products?

The experimental commodity group that could require that products be dropped to make space for stocking at a 99 percent level will be evaluated for sales and stockout levels using the same procedures described in question one, with only minor changes.

If products are dropped, then paired data between the two time periods would not be available for all products. If products are eliminated, an additional TTest will be used to compare the means of daily sales and stockouts in the commodity group as a whole to determine if there was a significant change in stockouts.

The posttset time period Tukey Test for differences in turnover ratios will not be performed on this product group, as turnover ratios were not used in the reallocation. A test will be performed to determine if the 99 percent customer service level requirement is met, given the second time periods average daily sales and product availability.

## Summary

This chapter presented the methodology of the shelf space reallocation experiment and the statistical tests used to evaluate the data. Chapter IV will present the data collected, the results of the tests and the significance of the results. Chapter V, the final chapter, will use the results to answer the research questions previously posed. The chapter will also present conclusions and recommendations for further research.

# IV. Analysis

## Background

This chapter is divided into four sections corresponding to the four areas discussed in the methodology of Chapter III. The first section describes the initial pretest data collection on sales and stockouts for the 3 product groups recommended by commissary management; the cake mix product group, the peanut butter product group, and the salad dressing product group. The sales data were tested to determine if the daily sales come from a normally distributed population. A Z-score based on sales and the amount of product available on the shelf was calculated to determine what level of customer demand could be met with the given shelf space allocation. Turnover ratios were also calculated and compared for significant difference.

The second section covers the reallocation of shelf space for two of the product groups. One product's shelf space was reallocated by equalizing the turnover ratios, and the other by allocating shelf space to ensure customer demand could be met 99 percent of the time. The third group's shelf space allocation was not be changed.

The third section presents the sales data for a time period after the reallocation. The data were tested for normalcy, turnover ratio and customer service level, which was defined as the level of demand that can be met given the available shelf space.

The fourth section is a comparison of the pre and posttest sales and out-of-stock data to determine if reallocation changed the stockout rate. The analysis used paired TTests and a Chi Square test to determine if changes in sales, stockouts and facings were dependent or independent of each other.

Initial Data Collection Period

The initial data collection period started on 28 May 1987, and lasted until 1 July 1987. Data for the week of 15-21 June were not used as the researcher did not collect the data, and errors in the data collected by other parties were indicated by sales figures and pull sheets for the warehouse restock crews. The remaining data cover 4 full weeks of operations, and include two pay periods. The pay periods are both end of month pay periods, and thus may not be representative of a normal month.

The daily sales data were collected from daily printouts of cumulative sales for each product. The commissary administrative section provided these printouts as a special service, as daily sales data were not normally maintained or printed. The data were adjusted to eliminate Wee Serve sales data for products of interest sold in both locations. Out-of-stock data were collected by the researcher after store closing and before restocking occurred. Out-of-stock situations were broken into two categories; out-of-stock on the shelf, and out-of-stock in

inventory. Out-of-stock on the shelf indicates product was available on the shelf at the start of the day, but sold out during the day. This research is directed towards lessening this situation. Out-of-stock in inventory indicates product was *not* available for sale at any time during the day, and that daily sales were in fact zero. Shelf space allocation does not affect this situation, but out-of-stock in inventory was tracked as it counted towards the goal of one percent total out-of-stock. If a product was out-of-stock in inventory, the daily sales for that product were treated as no data available. Counting it as zero sales would skew the distribution of sales and mean sales to the left. Counting it as no data available was valid as the real daily demand is unknown.

Peanut Butter Product Group. The peanut butter product group consisted of 21 products. The product group was authorized 12 feet linear feet of 5 tier shelving in the master store layout, but only 6 feet were allocated (12). The initial data period experienced high out-of-stock rates, which will be presented in section four. The product group experienced an average of 4.65 total stockouts per day. This high rate could mask the true demand for a product that was out-of-stock, as consumers take different actions when faced with a stockout, as discussed in Chapter 2.

The SAS UNIVARIATE Procedure results indicated that the distributions of the daily sales of all products were

approximately normal. The results of the Shapiro-Wilks Statistic are presented in Table 20 in Appendix A. The table also associates a product number with each product name. The product number is used in all further analysis and all other tables.

Table 1 lists the turnover analysis for the peanut butter product group. The "Sales Mean" is the average daily sales for each product, "Avail Units" is the number of units of product that can fit in the allocated shelf space and "Average Turnover" is mean sales divided by units available. The last column displays the results of the Tukey Test. The test is a multiple comparison of means that compared the turnover ratio of each product with the turnover ratios of all other products. The number in the last column is the number of other products with significantly different turnover ratios.

In this case an F Test with the null hypothesis that all turnover ratios were equal was rejected with an F value of 16.23 and a probability of a greater value of F of .000. The alternative hypothesis, that at least one turnover ratio was significantly different, was accepted. The range of turnover ratios was .07 to .59, indicating the products turned in a range of 14 to 1.67 days. The number of significant differences was fairly constant for most products, with two high and two low turnover ratios accounting for most of the differences.

Table 1. Turnover Analysis of Peanut Butter Product Group for Pretest Time Period

| Product Number | Sales Mean | Avail Units | Average Turnover | Sig.Diff. From |
|---|---|---|---|---|
| 1 | 26.50 | 48 | .55 | 12 |
| 2 | 34.88 | 72 | .48 | 7 |
| 3 | 6.25 | 60 | .10 | 11 |
| 4 | 10.58 | 72 | .15 | 9 |
| 5 | 29.29 | 60 | .49 | 3 |
| 6 | 9.25 | 30 | .30 | 4 |
| 7 | 5.47 | 42 | .13 | 9 |
| 8 | 17.70 | 48 | .37 | 2 |
| 9 | 18.00 | 48 | .38 | 6 |
| 10 | 8.75 | 48 | .18 | 5 |
| 11 | 8.67 | 18 | .48 | 8 |
| 12 | 25.58 | 60 | .43 | 6 |
| 13 | 16.54* | 48 | .34 | 7 |
| 14 | 42.46 | 72 | .59 | 13 |
| 15 | 26.13* | 60 | .44 | 6 |
| 16 | 3.35 | 15 | .22 | 7 |
| 17 | 4.42 | 15 | .29 | 3 |
| 18 | 7.41 | 24 | .31 | 3 |
| 19 | 6.30 | 24 | .26 | 4 |
| 20 | 6.92 | 54 | .13 | 9 |
| 21 | 3.71 | 54 | .07 | 13 |

* = product offered at lower than normal price

Table 2 shows the service level analysis for the peanut butter product group. The "Sales Mean" column lists the average daily sales, while the "Std. Dev. Sales" column lists the standard deviation of daily sales. The "Avail. Unit" column shows the amount of product available for sale, given the shelf space allocated and assuming full stocking. The Z-Score was calculated by subtracting Sales Mean from Avail Units, and dividing the difference by the standard deviation of sales. The result was used to enter a normal table to determine what percent of demand could be met given the allocated shelf space (10:214). The last column, "Service Level", is the level of demand that can be met given the sales level and allocated shelf space. The commissary has a goal of 99 percent service level for all products. The results show that the 99 percent level could be met for all except 3 products. The 3 products had service levels of 95, 96 and 97 percent. The range of Z scores was from 1.77 to 16. This indicated that some products had much more shelf space than was needed to meet the desired service level, while others could not meet the 99 percent goal. It is obvious, however, that no product has a serious deficiency in stock rate in this commodity group, since the 3 low-level products have a service level of 95 percent or better.

Cake Mix Product Group. The cake mix product group consisted of 31 products, and was authorized and allocated

Table 2. Service Level Analysis of Peanut Butter Product Group for Pretest Time Period

| Product Number | Sales Mean | Std. Dev. Sales | Avail Units | Z Score | Service Level |
|---|---|---|---|---|---|
| 1 | 26.50 | 9.04 | 48 | 2.38 | 99+ |
| 2 | 34.88 | 10.17 | 72 | 3.65 | 99+ |
| 3 | 6.25 | 3.43 | 60 | 15.67 | 99+ |
| 4 | 10.58 | 5.17 | 72 | 11.88 | 99+ |
| 5 | 29.29 | 11.01 | 60 | 2.79 | 99+ |
| 6 | 9.25 | 3.95 | 30 | 5.25 | 99+ |
| 7 | 5.47 | 3.31 | 42 | 11.04 | 99+ |
| 8 | 17.70 | 8.62 | 48 | 3.52 | 99+ |
| 9 | 18.00 | 16.92 | 48 | 1.77 | 96* |
| 10 | 8.75 | 4.80 | 48 | 8.18 | 99+ |
| 11 | 8.67 | 5.51 | 18 | 1.69 | 95* |
| 12 | 25.58 | 13.20 | 60 | 2.61 | 99+ |
| 13 | 16.54** | 10.48 | 48 | 3.00 | 99+ |
| 14 | 42.46 | 16.02 | 72 | 1.84 | 97* |
| 15 | 26.13** | 14.48 | 60 | 2.34 | 99+ |
| 16 | 3.35 | 2.40 | 15 | 4.85 | 99+ |
| 17 | 4.42 | 3.12 | 15 | 3.39 | 99+ |
| 18 | 7.41 | 5.45 | 24 | 3.04 | 99+ |
| 19 | 6.30 | 3.20 | 24 | 5.53 | 99+ |
| 20 | 6.92 | 4.45 | 54 | 10.58 | 99+ |
| 21 | 3.71 | 3.14 | 54 | 16.02 | 99+ |

* = failed to meet 99 percent in stock goal
** = product offered at lower than normal price

24 linear feet of shelf space. The out-of-stock rate was only .7 total stockouts per day, which should not impact the determination of demand. Table 21 in Appendix A gives the results of the normalcy tests and the product names. Based on the results of the Shapiro-Wilks Test, analysis of the plot of daily demand, and comparison of mean, median and mode, 30 products were assumed to have approximately normally distributed daily sales (32). Only product 22, Spice Cake, failed to show a normally distributed sales pattern.

The turnover analysis for the product group is presented in Table 3. The F test for the equality of turnover ratios resulted in a value of F of 20.35 with a probability of a value greater than F of .000. At least one turnover ratio was not equal to the other turnover ratios. The turnover ratios ranged from .11 to .7, however, 4 products accounted for most of the significant differences noted. The Z-scores presented in Table 4 show that the same four products had associated service levels of 77.3, 77.3, 93.7 and 94.2 percent. The remaining products had Z-scores that ranged from 3.87 to 17.66; indicating that much more product was available on the shelf than was necessary to meet the Z-score of 2.326 required for a 99 percent service level.

Dressing Product Group. The dressing product group was authorized 12 linear feet of 5 tier shelving, and was

Table 3. Turnover Analysis of Cake Mix Product Group for Pretest Time Period

| Product Number | Sales Mean | Avail Units | Average Turnover | Sig.Diff. From |
|---|---|---|---|---|
| 1 | 2.46 | 16 | .15 | 5 |
| 2 | 8.42 | 32 | .26 | 4 |
| 3 | 4.54 | 16 | .28 | 4 |
| 4 | 3.71 | 32 | .12 | 6 |
| 5 | 6.50 | 32 | .20 | 4 |
| 6 | 3.38 | 32 | .11 | 6 |
| 7 | 3.71 | 32 | .12 | 6 |
| 8 | 3.75 | 32 | .12 | 6 |
| 9 | 4.04 | 32 | .13 | 6 |
| 10 | 4.38 | 32 | .14 | 6 |
| 11 | 4.54 | 32 | .14 | 5 |
| 12 | 4.83 | 32 | .15 | 5 |
| 13 | 4.96 | 32 | .15 | 5 |
| 14 | 4.75 | 32 | .15 | 5 |
| 15 | 6.46 | 32 | .20 | 4 |
| 16 | 3.71 | 32 | .12 | 6 |
| 17 | 5.92 | 32 | .18 | 4 |
| 18 | 3.83 | 32 | .12 | 6 |
| 19 | 15.57 | 28 | .63 | 26 |
| 20 | 19.88 | 28 | .70 | 26 |
| 21 | 14.88 | 28 | .53 | 25 |
| 22 | 4.17 | 28 | .14 | * |
| 23 | 6.13 | 28 | .21 | 4 |
| 24 | 9.13 | 28 | .33 | 13 |
| 25 | 5.46 | 28 | .19 | 4 |
| 26 | 7.13 | 28 | .25 | 4 |
| 27 | 4.96 | 28 | .18 | 4 |
| 28 | 4.75 | 28 | .17 | 4 |
| 29 | 3.92 | 28 | .14 | 6 |
| 30 | 9.73 | 28 | .35 | 18 |
| 31 | 15.26 | 28 | .55 | 26 |

* = product sales not from a normal distribution

Table 4. Service Level Analysis of Cake Mix Product Group for the Pretest Time Period

| Product Number | Sales Mean | Std. Dev. Sales | Avail Units | Z Score | Service Level |
|---|---|---|---|---|---|
| 1 | 2.46 | 1.98 | 16 | 6.84 | 99+ |
| 2 | 8.42 | 4.51 | 32 | 5.32 | 99+ |
| 3 | 4.54 | 2.59 | 16 | 4.42 | 99+ |
| 4 | 3.71 | 2.51 | 32 | 11.27 | 99+ |
| 5 | 6.50 | 4.21 | 32 | 5.06 | 99+ |
| 6 | 3.38 | 2.32 | 32 | 12.34 | 99+ |
| 7 | 3.71 | 2.37 | 32 | 11.94 | 99+ |
| 8 | 3.75 | 3.47 | 32 | 8.14 | 99+ |
| 9 | 4.04 | 2.82 | 32 | 9.91 | 99+ |
| 10 | 4.38 | 2.72 | 32 | 10.15 | 99+ |
| 11 | 4.54 | 2.93 | 32 | 9.37 | 99+ |
| 12 | 4.83 | 2.91 | 32 | 9.34 | 99+ |
| 13 | 4.96 | 2.61 | 32 | 10.36 | 99+ |
| 14 | 4.75 | 4.29 | 32 | 6.35 | 99+ |
| 15 | 6.46 | 3.74 | 32 | 5.95 | 99+ |
| 16 | 3.71 | 1.60 | 32 | 17.68 | 99+ |
| 17 | 5.92 | 4.57 | 32 | 5.71 | 99+ |
| 18 | 3.83 | 2.82 | 32 | 9.99 | 99+ |
| 19 | 15.57 | 14.00 | 28 | 0.75 | 77.3* |
| 20 | 19.88 | 10.87 | 28 | 0.75 | 77.3* |
| 21 | 14.88 | 7.62 | 28 | 1.72 | 95.7* |
| 22 | 4.17 | 3.12 | 28 | ** | |
| 23 | 8.13 | 3.13 | 28 | 6.99 | 99+ |
| 24 | 9.13 | 4.88 | 28 | 3.87 | 99+ |
| 25 | 5.46 | 3.16 | 28 | 7.13 | 99+ |
| 26 | 7.13 | 4.41 | 28 | 4.73 | 99+ |
| 27 | 4.96 | 2.30 | 28 | 10.02 | 99+ |
| 28 | 4.75 | 2.51 | 28 | 9.26 | 99+ |
| 29 | 3.92 | 4.13 | 28 | 5.33 | 99+ |
| 30 | 9.73 | 5.33 | 28 | 3.43 | 99+ |
| 31 | 15.26 | 8.09 | 28 | 1.57 | 84.2* |

* = failure to meet 99 percent in stock goal
** = sales not from a normal distribution

allocated 12 linear feet (12). The product group contained 50 products. The dressing group had an average of 7.6 total stockouts per day. This high rate could mask the true demand for products. Some of these stockouts were due to missing labels on the shelf. The product was available in the warehouse, but was not stocked. If a product was out-of-stock on the shelf and the shelf label was missing, the stocker could not know what product to put in the empty space.

The UNIVARIATE test results are presented in Table 22 and Table 22 continued in Appendix A. The distribution of daily sales for all products was assumed to be approximately normal, based on the tests.

The turnover ratios are listed in Table 5 and Table 5 continued and ranged from .05 to .64, indicating products turned over once in a range of 20 to 1.5 days. The F test had a value of 26.27 with a probability of a value greater than F of .000. At least one turnover ratio was not equal to the other turnover ratios. The statistical distribution of turnover ratios were spread through the range, with a high number of significant differences evident.

The customer service levels are presented in Table 6 and Table 6 continued, and show that three products did not meet the 99 percent goal. The service levels were 98.9 percent, 97.7 percent and 97.7 percent. These values were very close to 99 percent goal. The remaining Z-scores range

Table 5. Turnover Analysis of Dressing Product Group for the Pretest Time Period

| Product Number | Sales Mean | Avail Units | Average Turnover | Sig.Diff. From |
|---|---|---|---|---|
| 1 | 11.22 | 50 | .22 | 9 |
| 2 | 6.57 | 36 | .18 | 8 |
| 3 | 11.44 | 40 | .29 | 20 |
| 4 | 8.43 | 70 | .12 | 18 |
| 5 | 18.17 | 40 | .45 | 36 |
| 6 | 17.87 | 48 | .37 | 29 |
| 7 | 5.13 | 56 | .09 | 19 |
| 8 | 10.70 | 36 | .30 | 22 |
| 9 | 17.14 | 56 | .31 | 22 |
| 10 | 25.45 | 40 | .64 | 46 |
| 11 | 8.48 | 30 | .28 | 21 |
| 12 | 9.91 | 56 | .18 | 8 |
| 13 | 6.91 | 36 | .19 | 8 |
| 14 | 19.29 | 50 | .39 | 28 |
| 15 | 29.26 | 60 | .49 | 39 |
| 16 | 7.28 | 40 | .18 | 8 |
| 17 | 7.78 | 56 | .14 | 15 |
| 18 | 5.61 | 56 | .10 | 19 |
| 19 | 6.13 | 36 | .17 | 8 |
| 20 | 18.65 | 60 | .31 | 22 |
| 21 | 10.36 | 30 | .35 | 22 |
| 22 | 13.91 | 60 | .23 | 11 |
| 23 | 27.09 | 50 | .54 | 43 |
| 24 | 7.64 | 40 | .19 | 8 |
| 25 | 7.30 | 50 | .15 | 13 |

Table 5 (cont). Turnover Analysis of Dressing Product Group for the Pretest Time Period

| Product Number | Sales Mean | Avail Units | Average Turnover | Sig.Diff. From |
|---|---|---|---|---|
| 26 | 4.87 | 70 | .07 | 24 |
| 27 | 9.6 | 40 | .24 | 11 |
| 28 | 18.05 | 56 | .32 | 22 |
| 29 | 2.17 | 45 | .05 | 24 |
| 30 | 7.15 | 45 | .16 | 10 |
| 31 | 9.35 | 30 | .31 | 18 |
| 32 | 5.26 | 45 | .12 | 13 |
| 33 | 7.82 | 45 | .17 | 8 |
| 34 | 9.81 | 30 | .33 | 23 |
| 35 | 17.89 | 39 | .46 | 32 |
| 36 | 9.87 | 39 | .25 | 11 |
| 37 | 8.04 | 90 | .09 | 19 |
| 38 | 3.83 | 39 | .10 | 19 |
| 39 | 5.35 | 60 | .09 | 19 |
| 40 | 3.26 | 39 | .08 | 20 |
| 41 | 14.83 | 45 | .33 | 20 |
| 42 | 4.43 | 60 | .07 | 23 |
| 43 | 6.04 | 60 | .10 | 19 |
| 44 | 5.74 | 75 | .08 | 23 |
| 45 | 16.82 | 60 | .28 | 19 |
| 46 | 14.25 | 52 | .27 | 11 |
| 47 | 44.52 | 70 | .64 | 46 |
| 48 | 4.52 | 52 | .09 | 20 |
| 49 | 3.52 | 72 | .05 | 24 |
| 50 | 7.43 | 52 | .14 | 15 |

Table 6. Service Level Analysis of Dressing Product Group for the Pretest Time Period

| Product Number | Sales Mean | Std. Dev. Sales | Avail Units | Z Score | Service Level |
|---|---|---|---|---|---|
| 1 | 11.22 | 4.39 | 50 | 8.83 | 99+ |
| 2 | 6.57 | 2.66 | 36 | 11.06 | 99+ |
| 3 | 11.44 | 5.78 | 40 | 4.93 | 99+ |
| 4 | 8.43 | 4.80 | 70 | 12.83 | 99+ |
| 5 | 18.17 | 5.98 | 40 | 3.65 | 99+ |
| 6 | 17.87 | 7.08 | 48 | 4.26 | 99+ |
| 7 | 5.13 | 2.80 | 56 | 18.17 | 99+ |
| 8 | 10.70 | 4.29 | 36 | 5.90 | 99+ |
| 9 | 17.14 | 9.52 | 56 | 4.08 | 99+ |
| 10 | 25.45 | 11.26 | 40 | 3.51 | 99+ |
| 11 | 8.48 | 4.15 | 30 | 5.19 | 99+ |
| 12 | 9.91 | 4.36 | 56 | 10.57 | 99+ |
| 13 | 6.91 | 4.55 | 36 | 6.39 | 99+ |
| 14 | 19.29 | 10.57 | 50 | 2.91 | 99+ |
| 15 | 29.26 | 13.29 | 60 | 2.31 | 98.9* |
| 16 | 7.28 | 3.54 | 40 | 9.26 | 99+ |
| 17 | 7.78 | 3.99 | 56 | 12.09 | 99+ |
| 18 | 5.61 | 2.87 | 56 | 17.56 | 99+ |
| 19 | 6.13 | 3.68 | 36 | 8.12 | 99+ |
| 20 | 18.65 | 9.19 | 60 | 4.50 | 99+ |
| 21 | 10.36 | 5.20 | 30 | 3.78 | 99+ |
| 22 | 13.91 | 5.70 | 60 | 8.09 | 99+ |
| 23 | 27.09 | 11.49 | 50 | 1.99 | 97.7* |
| 24 | 7.64 | 4.20 | 40 | 7.70 | 99+ |
| 25 | 7.30 | 4.35 | 50 | 9.82 | 99+ |

* = failed to meet 99 percent in stock goal

Table 6 (cont). Service Level Analysis of Dressing Product Group for the Pretest Time Period

| Product Number | Sales Mean | Std. Dev. Sales | Avail Units | Z Score | Service Level |
|---|---|---|---|---|---|
| 26 | 4.87 | 3.20 | 70 | 20.35 | 99+ |
| 27 | 9.6 | 4.79 | 40 | 6.35 | 99+ |
| 28 | 18.05 | 10.68 | 56 | 3.55 | 99+ |
| 29 | 2.17 | 1.77 | 45 | 24.20 | 99+ |
| 30 | 7.15 | 3.00 | 45 | 12.62 | 99+ |
| 31 | 9.35 | 4.58 | 30 | 4.51 | 99+ |
| 32 | 5.26 | 2.00 | 45 | 19.87 | 99+ |
| 33 | 7.82 | 3.63 | 45 | 10.24 | 99+ |
| 34 | 9.81 | 5.50 | 30 | 3.67 | 99+ |
| 35 | 17.89 | 8.12 | 39 | 2.60 | 99+ |
| 36 | 9.87 | 5.22 | 39 | 5.58 | 99+ |
| 37 | 8.04 | 4.20 | 90 | 19.51 | 99+ |
| 38 | 3.83 | 1.99 | 39 | 17.67 | 99+ |
| 39 | 5.35 | 3.58 | 60 | 15.27 | 99+ |
| 40 | 3.26 | 1.66 | 39 | 21.53 | 99+ |
| 41 | 14.83 | 5.97 | 45 | 5.05 | 99+ |
| 42 | 4.43 | 2.97 | 60 | 18.71 | 99+ |
| 43 | 6.04 | 2.85 | 60 | 18.93 | 99+ |
| 44 | 5.74 | 2.54 | 75 | 27.27 | 99+ |
| 45 | 16.82 | 8.78 | 60 | 4.92 | 99+ |
| 46 | 14.25 | 11.19 | 52 | 3.37 | 99+ |
| 47 | 44.52 | 22.01 | 70 | 1.16 | 87.7* |
| 48 | 4.52 | 2.39 | 52 | 19.87 | 99+ |
| 49 | 3.52 | 2.63 | 72 | 26.04 | 99+ |
| 50 | 7.43 | 3.79 | 52 | 11.76 | 99+ |

* = failed to meet the 99 percent in stock goal

from 2.6 to 27.27, indicating shelf space was not evenly allocated. Many products had much more space than was necessary to meet the 99 percent in stock goal.

Shelf Space Reallocation

The methodology called for the assignment of reallocation techniques on a random basis. This was not done. The cake mix product group had only a minor stockout problem, therefore reallocation of shelf space could not have a significant impact on the stockout situation. Because the cake mix group did not have a stockout problem, it was a logical choice for the control product group.

The peanut butter product group had little shelf space assigned, barely enough to reallocate to meet the 99 percent service goal. The turnover ratio analysis presented previously indicated the turnover ratios were already fairly constant, with most significant differences caused by four products. Therefore peanut butter was assigned to the 99 percent reallocation plan or group.

The dressing product group was allocated all of the shelf space authorized in the master store layout. The Z-scores and turnover ratios indicated much more shelf space available than was needed to meet the 99 percent service goal. Limiting product available to only that needed to meet the 99 percent goal would have required dropping 51 of 196 facings currently stocked. Other product groups would have had to be adjusted to fill this hole in the shelf

space. Therefore, dressing was assigned to the reallocation by equalizing turnover ratios treatment.

The purpose of this research was to test two different techniques to reallocate shelf space to control stockout problems. Used as a management tool the techniques would be used as appropriate to the situation, not randomly. To limit impacts on commissary operations, and to test the reallocation techniques in an appropriate situation, the reallocations were not random. The peanut butter product group will be reallocated to meet the 99 percent customer service goal, as available shelf space and sales levels favored this approach. The dressing product group received the equalized turnover ratio ratio treatment. It was recognized that the lack of random selection may limit the generalization of results to other product groups. Management, however, would not in real practice apply the techniques randomly, and the generalization to other similar situations should still be valid. Further, using a control group without a stockout problem will establish a conservative basis upon which to evaluate changes.

Peanut Butter Product Group. Table 7 shows the data used for reallocation calculations for the product group. The mean sales plus 2.326 standard deviations of sales gave the amount of product needed to meet demand 99 percent of the time. This figure, divided by the units per facing, gave the required number of facings to meet the 99 percent

Table 7. Reallocation Analysis of Peanut Butter Product Group by Required Service Level

| Product Number | Sales Mean | Std. Dev. Sales | Units Req. 99% Level | Units/ Facing | Facings Req. |
|---|---|---|---|---|---|
| 1 | 26.50 | 9.04 | 48 | 18 | 3 |
| 2 | 34.88 | 10.17 | 59 | 12 | 5 |
| 3 | 6.25 | 3.43 | 15 | 12 | 2 |
| 4 | 10.58 | 5.17 | 23 | 12 | 2 |
| 5 | 29.29 | 11.01 | 55 | 12 | 5 |
| 6 | 9.25 | 3.95 | 19 | 6 | 4 |
| 7 | 5.47 | 3.31 | 14 | 14 | 2 |
| 8 | 17.70 | 8.62 | 38 | 12 | 4 |
| 9 | 18.00 | 16.92 | 58 | 12 | 5 |
| 10 | 8.75 | 4.80 | 20 | 12 | 2 |
| 11 | 8.67 | 5.51 | 22 | 6 | 4 |
| 12 | 25.58 | 13.20 | 57 | 12 | 5 |
| 13 | 16.54 | 10.48 | 41 | 12 | 4 |
| 14 | 42.46 | 16.02 | 80 | 12 | 7 |
| 15 | 26.13 | 14.48 | 60 | 12 | 5 |
| 16 | 3.35 | 2.40 | 9 | 5 | 2 |
| 17 | 4.42 | 3.12 | 12 | 5 | 3 |
| 18 | 7.41 | 5.45 | 21 | 12 | 2 |
| 19 | 6.30 | 3.20 | 14 | 12 | 2 |
| 20 | 6.92 | 4.45 | 18 | 18 | 2 |
| 21 | 3.71 | 3.14 | 11 | 18 | 2 |

service goal. Stocking policy called for a minimum of two facings for each product to allow easier restock of the product. Table 8 shows the current facings, the required facings for 99 percent, and the facings actually allocated. Eight products had an extra facing allocated to balance the display vertically by brand, and horizontally by product type and container size. The last column shows the net change in facings from the initial allocation to the authorized facings in the reallocation. A store employee and the researcher performed the reallocation.

Dressing Product Group. The dressing product group reallocation analysis is shown in Table 9 and Table 9 continued. The tables show the current facings allocated, the current turnover ratios, proposed turnover ratios and the net change in facings. The proposed turnover ratios were calculated using the initial period demand and the units available in the proposed facings. The reallocation occurred as planned, except product 47 received only 7 additional facings instead of the planned 10, due to space limitations. Product 47 was sold at a lower than normal price during part of the initial data collection period. Sales declined when the product price returned to normal. The lower price appeared to cause an increase in demand for the product. The shelf space was calculated based on this higher than normal demand. The lower shelf space should not impact stockouts, as demand was significantly lower once the price returned to normal.

Table 8. Reallocation of Peanut Butter Product Group by Required Service Level

| Product Number | Current Facings | Facings for 99% | Approved Facings | Change in Facings |
|---|---|---|---|---|
| 1 | 4 | 3 | 3 | -1 |
| 2 | 6 | 5 | 6 | 0 |
| 3 | 5 | 2 | 3 | -2 |
| 4 | 6 | 2 | 3 | -3 |
| 5 | 5 | 5 | 6 | +1 |
| 6 | 5 | 4 | 5 | 0 |
| 7 | 3 | 2 | 2 | -1 |
| 8 | 4 | 4 | 4 | 0 |
| 9 | 4 | 5 | 5 | +1 |
| 10 | 4 | 2 | 3 | -1 |
| 11 | 3 | 4 | 4 | +1 |
| 12 | 5 | 5 | 6 | +1 |
| 13 | 4 | 4 | 5 | +1 |
| 14 | 6 | 7 | 8 | +2 |
| 15 | 5 | 5 | 6 | +1 |
| 16 | 3 | 2 | 3 | 0 |
| 17 | 3 | 3 | 3 | 0 |
| 18 | 2 | 2 | 2 | 0 |
| 19 | 2 | 2 | 2 | 0 |
| 20 | 3 | 2 | 2 | -1 |
| 21 | 3 | 2 | 2 | -1 |

Table 9. Reallocation of Dressing Product Group by Equalizing Turnover Ratios

| Product Number | Current Facings | Average Turnover | Proposed Facings | Proposed Turnover | Facing Change |
|---|---|---|---|---|---|
| 1 | 5 | .22 | 4 | .28 | -1 |
| 2 | 3 | .18 | 2 | .27 | -1 |
| 3 | 4 | .29 | 4 | .29 | 0 |
| 4 | 5 | .12 | 3 | .20 | -2 |
| 5 | 4 | .45 | 5 | .36 | +1 |
| 6 | 4 | .37 | 5 | .30 | +1 |
| 7 | 4 | .09 | 2 | .18 | -2 |
| 8 | 3 | .30 | 3 | .30 | 0 |
| 9 | 4 | .31 | 5 | .24 | +1 |
| 10 | 4 | .64 | 8 | .32 | +4 |
| 11 | 3 | .28 | 3 | .28 | 0 |
| 12 | 4 | .18 | 3 | .24 | -1 |
| 13 | 3 | .19 | 3 | .19 | 0 |
| 14 | 5 | .39 | 7 | .28 | +2 |
| 15 | 6 | .49 | 10 | .29 | +4 |
| 16 | 5 | .18 | 2 | .26 | -3 |
| 17 | 4 | .14 | 2 | .28 | -2 |
| 18 | 4 | .10 | 2 | .20 | -2 |
| 19 | 3 | .17 | 2 | .26 | -1 |
| 20 | 6 | .31 | 7 | .27 | +1 |
| 21 | 3 | .35 | 4 | .26 | +1 |
| 22 | 6 | .23 | 5 | .28 | -1 |
| 23 | 3 | .54 | 9 | .30 | +6 |
| 24 | 4 | .19 | 3 | .25 | -1 |
| 25 | 5 | .15 | 3 | .24 | -2 |

Table 9 (cont). Reallocation of Dressing Product Group by Equalizing Turnover Ratios

| Product Number | Current Facings | Average Turnover | Proposed Facings | Proposed Turnover | Facing Change |
|---|---|---|---|---|---|
| 26 | 5 | .07 | 2 | .17 | -3 |
| 27 | 4 | .24 | 4 | .24 | 0 |
| 28 | 4 | .32 | 5 | .26 | +1 |
| 29 | 3 | .05 | 2 | .07 | -1 |
| 30 | 3 | .16 | 2 | .23 | -1 |
| 31 | 2 | .31 | 3 | .21 | +1 |
| 32 | 3 | .12 | 2 | .17 | -1 |
| 33 | 3 | .17 | 2 | .27 | -1 |
| 34 | 2 | .33 | 3 | .22 | +1 |
| 35 | 3 | .46 | 5 | .28 | +2 |
| 36 | 3 | .25 | 3 | .25 | 0 |
| 37 | 6 | .09 | 2 | .27 | -4 |
| 38 | 3 | .10 | 2 | .15 | -1 |
| 39 | 4 | .09 | 2 | .18 | -2 |
| 40 | 3 | .08 | 2 | .14 | -1 |
| 41 | 3 | .33 | 3 | .15 | 0 |
| 42 | 4 | .07 | 2 | .20 | -2 |
| 43 | 4 | .10 | 2 | .20 | -2 |
| 44 | 5 | .08 | 2 | .19 | -3 |
| 45 | 5 | .28 | 5 | .28 | 0 |
| 46 | 4 | .27 | 5 | .22 | +1 |
| 47 | 5 | .64 | 15 | .30 | +10 |
| 48 | 4 | .09 | 2 | .17 | -2 |
| 49 | 6 | .05 | 2 | .15 | -4 |
| 50 | 4 | .14 | 2 | .29 | -2 |

The reallocation required that some products be moved to different shelf levels. The experiment was not designed to consider differences in sales that could be caused by differences in shelf height. Six products were moved to different levels, four higher and two lower. Three of the four products moved higher did not show a significant change in sales, while the fourth showed a significant decrease. One of the two products moved to lower shelves showed no significant change in sales, while the other showed a significant decrease. These trends in sales did not differ from the overall trends in sales. It was concluded based upon this analysis that the change in shelf height for these products did not significantly affect their sales levels.

Posttest Data Collection Period

The second data collection period started on 14 July 1987, and ended 9 August 1987. The time period included 2 pay periods, and provided the 24 daily data points required for paired TTests with the first time period. The same data collection techniques were used for both time periods. The number of out-of-stock situations were much lower for this time period, which should have provided better data on actual daily customer demand.

Peanut Butter Product Group. Table 23 in Appendix A shows the results of the normalcy tests. All daily sales data come from an approximately normal distribution. Product nine was never in stock, and sales data for product

20 were not recorded by ACDS. The product was listed as dropped, but was added back before all stocks were depleted.

Table 10 lists the daily sales figures for the second time period, and shows the results of the service level analysis. The figures indicate that all products had sufficient shelf space to stock product to meet the 99 percent service level. Data for products 9 and 20 were not available for the reasons previously discussed. Products five and six were offered at a lower price than normal. The price was lowered from $4.10 to $2.95 for 40 ounce Crunchy and Creamy Jiff. A special display provided a large supply of the products, well in excess of the increased daily demand. The price was only 5 cents more than the 28 ounce size of the same product. This situation made it impossible to determine a service level for these products. The higher sales could have meant lower sales in different sizes of the same brand, or of competiting products. To further complicate matters, two more products were added to the product group during the last weeks of data collection. The sales of these two products could not be factored into the analysis, and their sales may have affected the sales of competing products in the product group. These problems are addressed later in this chapter.

Cake Mix Product Group. Table 24 in Appendix A lists the results of the normalcy tests. Based on the test results, all products daily sales, except product 22, are

Table 10. Service Level Analysis of Peanut Butter Product Group for Posttest Time Period

| Product Number | Sales Mean | Std. Dev. Sales | Avail Units | Z Score | Service Level |
|---|---|---|---|---|---|
| 1 | 21.83 | 6.00 | 54 | 5.71 | 99+ |
| 2 | 23.08 | 11.37 | 72 | 4.30 | 99+ |
| 3 | 5.75 | 3.98 | 33 | 7.80 | 99+ |
| 4 | 11.17 | 7.06 | 3 | 3.52 | 99+ |
| 5 | 66.42 | 36.77 | * | | 99+ |
| 6 | 35.25 | 18.97 | * | | 99+ |
| 7 | 3.88 | 3.48 | 23 | 6.93 | 99+ |
| 8 | 9.39 | 6.93 | 48 | 5.57 | 99+ |
| 9 | ** | | | | |
| 10 | 7.04 | 3.24 | 36 | 8.94 | 99+ |
| 11 | 4.46 | 3.28 | 24 | 5.96 | 99+ |
| 12 | 20.38 | 11.89 | 72 | 4.34 | 99+ |
| 13 | 6.08 | 3.89 | 48 | 10.78 | 99+ |
| 14 | 37.58 | 14.46 | 96 | 4.04 | 99+ |
| 15 | 10.46 | 5.14 | 60 | 9.46 | 99+ |
| 16 | 3.08 | 2.10 | 15 | 5.68 | 99+ |
| 17 | 2.46 | 2.25 | 15 | 5.57 | 99+ |
| 18 | 7.52 | 4.64 | 24 | 3.55 | 99+ |
| 19 | 5.94 | 3.17 | 24 | 5.70 | 99+ |
| 20 | *** | | | | |
| 21 | 2.63 | 2.50 | 36 | 13.55 | 99+ |

* = sold at lower than normal price with extra stock available
** = out-of-stock entire period
*** = data not collected by ACOS

assumed to come from an approximately normal distribution. All other data on sales and stockouts will be presented in the analysis section.

Dressing Product Group. Table 25 and Table 25 continued in Appendix A lists the results of the daily sales normalcy tests. Based on the tests, all products daily sales were assumed to come from an approximately normal distribution.

Table 11 and Table 11 continued show the pretest and posttest average turnover ratios. The number of significant differences appeared to be lower in the posttest time period. The pretest turnover ratios had a range of .05 to .64, compared to a posttest range of .06 to .40. A TTest comparing the number of significantly different turnover ratios for each product indicated the posttest period had significantly fewer differences. The TTest showed the time periods had a significant difference, with T of -5.06 and a probability of a value greater than T of .0001. This indicated the reallocation of shelf space by equalizing turnover ratios did, in fact, tend to equalize the turnover ratios.

## Data Analysis

Data on the daily sales for the grocery department of the commissary are listed in Table 26 in Appendix B. The data were collected for the pre and posttest time periods. A paired TTest of the data indicated the sales were trending

Table 11. Comparison of Pre and Posttest Turnover Ratios for Dressing Product Group

| Product Number | Pretest Turnover Ratio | Pretest # Sig Diff | Posttest Turnover Ratio | Posttest # Sig Diff |
|---|---|---|---|---|
| 1 | .22 | 9 | .34* | 37 |
| 2 | .16 | 6 | .23 | 4 |
| 3 | .29 | 20 | .27 | 16 |
| 4 | .12 | 16 | .15 | 7 |
| 5 | .45 | 36 | .30 | 27 |
| 6 | .37 | 29 | .27 | 15 |
| 7 | .09 | 19 | .12 | 12 |
| 8 | .30 | 22 | .19 | 3 |
| 9 | .31 | 22 | .21 | 4 |
| 10 | .64* | 46 | .22 | 4 |
| 11 | .28 | 21 | .18 | 6 |
| 12 | .18 | 8 | .18 | 5 |
| 13 | .19 | 8 | .13 | 10 |
| 14 | .39* | 28 | .24 | 6 |
| 15 | .49* | 39 | .17 | 5 |
| 16 | .16 | 8 | .24 | 5 |
| 17 | .14* | 15 | .19* | 4 |
| 18 | .10 | 19 | .18 | 6 |
| 19 | .17 | 8 | .17 | 5 |
| 20 | .31* | 22 | .23* | 4 |
| 21 | .35 | 22 | .18 | 6 |
| 22 | .23 | 11 | .40 | 45 |
| 23 | .54 | 43 | .15 | 7 |
| 24 | .19 | 8 | .21 | 4 |
| 25 | .15 | 13 | .13 | 10 |

* = product sold at lower than normal price

Table 11 (cont). Comparison of Pre and Posttest Turnover Ratios for Dressing Product Group

| | Pretest | | Posttest | |
|---|---|---|---|---|
| Product Number | Turnover Ratio | # Sig Diff | Turnover Ratio | # Sig Diff |
| 26 | .26 | 24 | .15 | 9 |
| 27 | .24 | 11 | .25 | 11 |
| 28 | .32 | 22 | .16 | 6 |
| 29 | .05 | 24 | .06 | 23 |
| 30 | .16 | 10 | .14 | 9 |
| 31 | .31 | 18 | .18 | 6 |
| 32 | .12 | 18 | .13 | 10 |
| 33 | .17 | 8 | .17 | 5 |
| 34 | .33 | 23 | .19 | 4 |
| 35 | .46 | 32 | .30 | 29 |
| 36 | .25 | 11 | .19 | 1 |
| 37 | .09 | 19 | .17 | 5 |
| 38 | .10* | 19 | .15 | 9 |
| 39 | .09 | 19 | .12 | 12 |
| 40 | .08* | 20 | .11 | 10 |
| 41 | .33 | 20 | .27 | 14 |
| 42 | .07 | 23 | .13 | 10 |
| 43 | .10 | 19 | .16 | 5 |
| 44 | .08 | 23 | .17 | 5 |
| 45 | .28 | 19 | .29 | 26 |
| 46 | .27 | 11 | .26 | 14 |
| 47 | .64 | 46 | .19 | 3 |
| 48 | .09 | 20 | .13 | 11 |
| 49 | .05 | 24 | .09 | 17 |
| 50 | .14 | 15 | .19 | 3 |

downward in the posttest time period, but not significantly lower. The TTest showed a T of -1.09 and a probability of a value greater than T of .287. This trend towards lower sales was reflected in the individual product group data, which follow.

The data for the paired TTests were also blocked by day of the week. The commissary was open different hours on different days. The pairing by days takes the differences in operating hours into consideration, and eliminates variation caused by these differences in operating hours.

Cake Mix Product Group. Table 12 provides the results of the paired TTest to determine if the mean daily sales are significantly different between the two time periods for each product group. The TTest computes a difference for each product by subtracting the pretest average daily sales from the posttest average daily sales. A negative T indicates the sales decreased in the posttest time period. The results indicate the overall trend in sales was down. Sixty percent of the products did not have a significant change in sales between the two time periods, three percent showed an increase in sales and thirty-seven percent showed a significant decrease in sales.

Table 13 shows the out-of-stock levels for the two time periods on a daily basis. The "O-o-S Shelf" column shows out-of-stock on the shelf, which indicates product was on the shelf at the start of the day, and sold out during the

Table 12. Paired TTest of Daily Sales for the Cake Mix Product Group

| Product Number | Average Diff | Std Dev | T | Prob T | Sig Diff |
|---|---|---|---|---|---|
| 1 | -0.54 | .39 | -1.39 | .178 | 0 |
| 2 | -2.50 | .96 | -2.60 | .016 | - |
| 3 | -0.54 | .64 | -0.84 | .408 | 0 |
| 4 | -2.29 | .52 | -4.44 | .000 | - |
| 5 | -1.79 | .92 | -1.95 | .064 | 0 |
| 6 | -1.33 | .46 | -2.89 | .008 | - |
| 7 | -0.08 | .74 | -0.11 | .911 | 0 |
| 8 | -1.54 | 1.24 | -1.24 | .238 | 0 |
| 9 | 0.50 | .67 | 0.75 | .462 | 0 |
| 10 | -2.00 | .60 | -3.32 | .003 | - |
| 11 | -0.83 | .66 | -1.26 | .220 | 0 |
| 12 | -1.75 | .69 | -2.54 | .018 | - |
| 13 | -2.46 | .71 | -3.44 | .002 | - |
| 14 | 2.63 | 1.12 | 2.34 | .029 | + |
| 15 | 0.79 | .74 | 1.06 | .302 | 0 |
| 16 | 0.38 | .48 | 0.77 | .447 | 0 |
| 17 | -1.87 | 1.00 | -1.87 | .074 | 0 |
| 18 | -1.67 | .57 | -2.91 | .008 | - |
| 19 | -7.38 | 3.14 | -2.35 | .033 | - |
| 20 | -1.54 | 2.91 | -0.53 | .601 | 0 |
| 21 | -5.78 | 2.37 | -2.43 | .026 | - |
| 22 | * | | | | |
| 23 | -0.17 | .90 | -0.19 | .854 | 0 |
| 24 | -0.44 | 1.38 | -0.32 | .752 | 0 |
| 25 | -1.04 | .71 | -1.47 | .155 | 0 |
| 26 | -1.06 | 1.28 | -0.83 | .420 | 0 |
| 27 | 3.00 | 1.57 | 1.91 | .069 | 0 |
| 28 | 1.83 | .95 | 1.92 | .067 | 0 |
| 29 | -2.40 | 2.98 | -0.81 | .465 | 0 |
| 30 | -3.77 | 1.29 | -2.92 | .008 | - |
| 31 | -5.83 | 1.70 | -3.42 | .003 | - |

* = data not from a Normal Distribution

Table 13. Out-of-Stock Data by Day
for the Cake Mix (Control) Product Group

| | Pretest | | | Posttest | | |
|---|---|---|---|---|---|---|
| Day | O-o-S Shelf | O-o-S Inven | O-o-S Total | O-o-S Shelf | O-o-S Inven | O-o-S Total |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 2 | 2 | 1 | 3 | 0 | 1 | 1 |
| 3 | 0 | 0 | 0 | 0 | 1 | 1 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 2 | 0 | 2 |
| 6 | 0 | 0 | 0 | 0 | 2 | 2 |
| 7 | 0 | 0 | 0 | 0 | 2 | 2 |
| 8 | 1 | 0 | 1 | 0 | 2 | 2 |
| 9 | 1 | 0 | 1 | 1 | 2 | 3 |
| 10 | 0 | 0 | 0 | 0 | 3 | 3 |
| 11 | 0 | 0 | 0 | 0 | 3 | 3 |
| 12 | 0 | 0 | 0 | 1 | 2 | 3 |
| 13 | 2 | 0 | 2 | 0 | 2 | 2 |
| 14 | 0 | 0 | 0 | 0 | 2 | 2 |
| 15 | 1 | 0 | 1 | 0 | 2 | 2 |
| 16 | 0 | 1 | 1 | 0 | 2 | 2 |
| 17 | 0 | 0 | 0 | 0 | 2 | 2 |
| 18 | 0 | 1 | 1 | 0 | 1 | 1 |
| 19 | 0 | 2 | 2 | 1 | 1 | 2 |
| 20 | 0 | 1 | 1 | 0 | 2 | 2 |
| 21 | 0 | 0 | 0 | 0 | 2 | 2 |
| 22 | 1 | 0 | 1 | 0 | 2 | 2 |
| 23 | 0 | 0 | 0 | 0 | 1 | 1 |
| 24 | 0 | 0 | 0 | 0 | 1 | 0 |

day. The "O-o-S Inven" column shows no stock on the shelf at store opening and "O-o-S Total" is the sum of the first two columns. A paired TTest comparing the average daily stockouts on the shelf for the two time periods showed not enough evidence was available to reject the null hypothesis that the daily stockout averages were equal, therefore no conclusion could be reached on whether stockout levels changed between the two time periods. The value of T was -0.94 with a probability of .357 of finding a value greater than T. The mean difference is -0.17 with a standard deviation of 0.18. The data covered 24 days, with 25 percent of the products showing a drop in stockouts, 63 percent showing no significant change and 12 percent with an increase in stockouts.

Dressing Product Group. Table 14 and Table 14 continued provide the results of the paired TTests for differences of daily sales means for the dressing product group. Again, the pretest values were subtracted from the posttest values, thus, negative values indicate a drop in sales for the posttest time period. Forty percent of the products showed a significant decrease in average daily sales, fifty-four percent showed no change and six percent showed a significant increase in sales.

Table 15 shows the daily stockouts for the product group taken as a whole. The data of interest are the out-of-stock on the shelf figures for the pre and posttest

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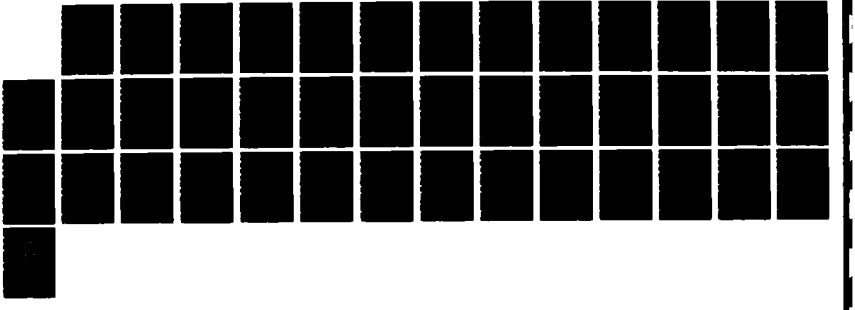

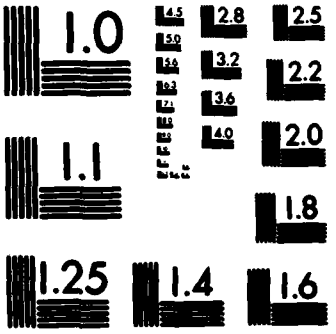


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Table 14. Paired TTest of Daily Sales for the Dressing Product Group

| Product Number | Average Diff*** | Std Dev | T | Prob T | Sig Diff |
|---|---|---|---|---|---|
| 1 | 4.74** | 1.07 | 4.44 | .000 | + |
| 2 | -1.57 | .81 | -1.92 | .068 | 0 |
| 3 | 0.78 | 1.45 | 0.53 | .600 | 0 |
| 4 | -2.48 | .98 | -2.52 | .019 | - |
| 5 | -1.74 | 1.52 | -1.15 | .264 | 0 |
| 6 | -1.83 | 2.00 | -.091 | .372 | 0 |
| 7 | -1.83 | .67 | -2.74 | .012 | - |
| 8 | -3.43 | .80 | -4.29 | .000 | - |
| 9 | -3.29 | 2.26 | -1.45 | .160 | 0 |
| 10 | -5.91* | 2.53 | -2.34 | .030 | - |
| 11 | -2.57 | 1.06 | -2.43 | .025 | - |
| 12 | -1.35 | 1.06 | -1.28 | .216 | 0 |
| 13 | -2.13 | .95 | -2.24 | .036 | - |
| 14 | -0.24* | 2.39 | -0.10 | .922 | 0 |
| 15 | -10.70* | 2.90 | -3.69 | .001 | - |
| 16 | -0.70 | .75 | -0.93 | .362 | 0 |
| 17 | -2.61* ** | .82 | -3.81 | .004 | - |
| 18 | -0.65 | .62 | -1.05 | .305 | 0 |
| 19 | -1.56 | .86 | -1.81 | .084 | 0 |
| 20 | -19.61* ** | 18.36 | -1.07 | .298 | 0 |
| 21 | -2.07 | 1.43 | -1.45 | .171 | 0 |
| 22 | 7.87 | 1.95 | 4.04 | .000 | + |
| 23 | -12.26 | 2.53 | -4.84 | .000 | - |
| 24 | -1.73 | 1.56 | -1.11 | .293 | 0 |
| 25 | -2.83 | .87 | -3.25 | .004 | - |

* = sale and extra shelf space pretest period
** = sale and extra shelf space posttest period
*** = average difference = posttest - pretest

Table 14 (cont). Paired TTest of Daily Sales for the Dressing Product Group

| Product Number | Average Diff | Std Dev | T | Prob T | Sig Diff |
|---|---|---|---|---|---|
| 26 | -1.00 | .97 | -1.03 | .316 | 0 |
| 27 | 0.85 | 1.41 | 0.60 | .555 | 0 |
| 28 | -6.24 | 2.35 | -2.65 | .017 | - |
| 29 | -0.48 | .47 | -1.01 | .320 | 0 |
| 30 | -2.30 | .56 | -4.12 | .000 | - |
| 31 | -1.14 | .99 | -1.15 | .271 | 0 |
| 32 | -1.39 | .49 | -2.82 | .010 | - |
| 33 | -2.91 | .75 | -3.90 | .000 | - |
| 34 | -1.57 | 1.45 | -1.09 | .290 | 0 |
| 35 | 1.72 | 2.23 | 0.77 | .451 | 0 |
| 36 | -0.25 | 3.90 | -0.06 | .953 | 0 |
| 37 | -3.09 | .99 | -3.11 | .005 | - |
| 38 | 0.00* | .56 | 0.00 | 1.000 | 0 |
| 39 | -2.00 | .74 | -2.70 | .014 | - |
| 40 | -1.08* | .69 | -1.57 | .145 | 0 |
| 41 | -3.30 | 1.45 | -2.27 | .049 | - |
| 42 | -0.48 | .79 | -0.61 | .550 | 0 |
| 43 | -1.26 | .72 | -1.74 | .095 | 0 |
| 44 | -0.74 | .63 | -1.18 | .251 | 0 |
| 45 | 0.72 | 2.63 | 0.27 | .787 | 0 |
| 46 | 5.04 | 2.28 | 2.22 | .037 | + |
| 47 | -18.50* | 4.95 | -3.73 | .001 | - |
| 48 | -1.48 | .61 | -2.43 | .024 | - |
| 49 | -1.26 | .67 | -1.88 | .074 | 0 |
| 50 | -2.70 | 1.19 | -2.26 | .035 | - |

* = sale and extra shelf space pretest period

Table 15. Out-of-Stock Data by Day for the Dressing Product Group

| | Pretest | | | Posttest | | |
|---|---|---|---|---|---|---|
| Day | O-o-S Shelf | O-o-S Inven* | O-o-S Total | O-o-S Shelf | O-o-S Inven | O-o-S Total |
| 1 | 10 | 3 | 13 | 1 | 4 | 5 |
| 2 | 12 | 4 | 16 | 1 | 1 | 2 |
| 3 | 7 | 1 | 8 | 3 | 1 | 4 |
| 4 | 4 | 3 | 7 | 2 | 2 | 4 |
| 5 | 3 | 6 | 9 | 0 | 2 | 2 |
| 6 | 5 | 4 | 9 | 0 | 2 | 2 |
| 7 | 5 | 3 | 8 | 0 | 1 | 1 |
| 8 | 5 | 2 | 7 | 0 | 1 | 1 |
| 9 | 1 | 2 | 3 | 1 | 1 | 2 |
| 10 | 4 | 2 | 6 | 0 | 1 | 1 |
| 11 | 2 | 4 | 6 | 0 | 1 | 1 |
| 12 | 4 | 4 | 8 | 1 | 1 | 2 |
| 13 | 2 | 5 | 7 | 0 | 2 | 2 |
| 14 | 2 | 5 | 7 | 1 | 2 | 3 |
| 15 | 1 | 7 | 8 | 2 | 3 | 5 |
| 16 | 1 | 4 | 5 | 0 | 4 | 4 |
| 17 | 4 | 3 | 7 | 0 | 2 | 2 |
| 18 | 3 | 3 | 6 | 0 | 2 | 2 |
| 19 | 1 | 3 | 4 | 0 | 2 | 2 |
| 20 | 6 | 2 | 8 | 0 | 2 | 2 |
| 21 | 1 | 5 | 6 | 0 | 1 | 1 |
| 22 | 3 | 5 | 8 | 0 | 1 | 1 |
| 23 | 4 | 4 | 8 | 0 | 2 | 2 |

* = three products out-of-stock due to missing shelf labels

periods. A paired TTest on the differences of the means indicated a significant decrease in stockouts for the posttest time period. The value of T was -5.93, with a probability of a value greater than T of .0001. The null hypothesis that there was no difference in the means was rejected, and the alternative hypothesis was accepted. The mean difference, calculated by subtracting the pretest data from the posttest data, was -3.39 stockouts, with a standard deviation of 0.57. Overall stockouts decreased significantly for the product group. Data from Table 16, which lists stockouts by individual products, shows that 40 percent of the products had no change in stockout levels, 52 percent showed a decrease in stockouts and 8 percent showed an increase.

Table 16 and Table 16 continued show the stockout situation for individual products, with the change in facings from the pre to posttest period included. Data were now available for sales, facing changes and direction of change in stockouts for individual products. A contingency table was appropriate to compare these changes to determine if they were independent of each other. This was necessary to determine if the change in sales was related to the change in stockouts or the change in facings. A dependency between two of the factors would have implied a causal relationship. The null hypothesis for the contingency table was that the factors were independent. A Chi Square test

Table 16. Out-of-Stock Data for Individual Products in the Dressing Product Group

| Product Number | Out-of-Stock on the Shelf | | Change in Facings | Out-of-Stock in Inventory | |
|---|---|---|---|---|---|
| | Pre Test | Post Test | | Pre Test | Post Test |
| 1 | 0 | 0 | -1 | 0 | 0 |
| 2 | 1 | 0 | -1 | 0 | 0 |
| 3 | 2 | 2 | 0 | 5 | 0 |
| 4 | 2 | 0 | -2 | 0 | 0 |
| 5 | 4 | 2 | 1 | 0 | 0 |
| 6 | 2 | 1 | 1 | 0 | 0 |
| 7 | 0 | 0 | -2 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 |
| 9 | 7 | 0 | 1 | 2 | 0 |
| 10 | 6 | 0 | 4 | 1 | 0 |
| 11 | 2 | 1 | 0 | 2 | 0 |
| 12 | 2 | 0 | -1 | 0 | 0 |
| 13 | 1 | 0 | 0 | 0 | 0 |
| 14 | 9 | 0 | 2 | 6 | 0 |
| 15 | 3 | 0 | 4 | 0 | 0 |
| 16 | 0 | 0 | -3 | 0 | 0 |
| 17 | 0 | 0 | -2 | 0 | 0 |
| 18 | 0 | 0 | -2 | 0 | 0 |
| 19 | 0 | 0 | -1 | 0 | 0 |
| 20 | 0 | 0 | 1 | 0 | 0 |
| 21 | 1 | 0 | 1 | 9 | 0 |
| 22 | 0 | 0 | -1 | 0 | 0 |
| 23 | 1 | 0 | 6 | 0 | 0 |
| 24 | 3 | 1 | -1 | 8 | 3 |
| 25 | 3 | 0 | -2 | 0 | 0 |

Table 16 (cont). Out-of-Stock Data for Individual Products in the Dressing Product Group

| Product Number | Out-of-Stock on the Shelf: Pre Test | Out-of-Stock on the Shelf: Post Test | Change in Facings | Out-of-Stock in Inventory: Pre Test | Out-of-Stock in Inventory: Post Test |
|---|---|---|---|---|---|
| 26 | 0 | 0 | -3 | 0 | 0 |
| 27 | 6 | 1 | 0 | 3 | 0 |
| 28 | 6 | 0 | 1 | 4 | 1 |
| 29 | 0 | 0 | -1 | 0 | 0 |
| 30 | 4 | 0 | -1 | 3 | 0 |
| 31 | 2 | 0 | 1 | 9 | 0 |
| 32 | 0 | 0 | -1 | 0 | 0 |
| 33 | 1 | 0 | -1 | 0 | 0 |
| 34 | 3 | 0 | 1 | 2 | 0 |
| 35 | 3 | 1 | 2 | 5 | 0 |
| 36 | 6 | 2 | 0 | 7 | 18 |
| 37 | 0 | 0 | -4 | 0 | 0 |
| 38 | 0 | 0 | -1 | 0 | 0 |
| 39 | 0 | 1 | -2 | 0 | 2 |
| 40 | 0 | 1 | -1 | 0 | 10 |
| 41 | 3 | 0 | 0 | 11 | 3 |
| 42 | 0 | 0 | -2 | 0 | 0 |
| 43 | 1 | 0 | -2 | 0 | 0 |
| 44 | 0 | 0 | -3 | 0 | 0 |
| 45 | 8 | 1 | 0 | -5 | 0 |
| 46 | 0 | 0 | 1 | 0 | 0 |
| 47 | 0 | 1 | 10 | 2 | 1 |
| 48 | 0 | 0 | -2 | 0 | 0 |
| 49 | 0 | 0 | -4 | 0 | 0 |
| 50 | 0 | 3 | -2 | 0 | 3 |

statistic for an alpha of .05 and 1 degree of freedom was 3.84. A value less than that from the contingency table does not provide enough evidence to disprove the null hypothesis. A value greater than 3.84 caused rejection of the null hypothesis, and acceptance of the alternative hypothesis of dependency (20:799).

Table 27 and Table 27 continued are found in Appendix B. These data were used to construct the contingency tables at Figures 1, 2 and 3. The data show the direction of change for sales, stockouts and facings for all 50 products. The contingency tables were developed using no change and increase as one factor and a decrease as the second factor. This was done to ensure five values per cell were available, since the number of increases were too small to use as a separate factor and still have 5 values per cell. In addition, the two categories served to make the Chi Square test more conservative; more decreases will be required due to the facing change than would have been required before in order to show statistical significance.

Figure 1 details the test of whether the relationship between the change in sales and change in facings were independent. The value in the bottom of each cell is the expected value, assuming independence. The value near the center of the cell is the value actually found from the collected data. Figure 1 shows a Chi Square value of .013. This is less than the test statistic of 3.84. There is not

enough evidence to reject the null hypothesis of independence between changes in facings and changes in sales for salad dressing. Thus changing the number of facings did not appear to cause a decrease in sales.

Figure 2 tests the relationship between the direction of change in sales and the direction of change in stockouts. The Chi Square value was .121, which was less than the test statistic of 3.84. There was not enough evidence to reject the null hypothesis of independence between the direction of change for sales and stockouts. That is, although sales declined slightly in total, declines in sales for products did not cause a decline in stockouts for those same items.

Figure 3 tests the relationship between stockouts and changes in facings made during the reallocation. The Chi Square value for the table was 12.0, which was greater than the test statistic of 3.84, and which has a probability of the result being due to chance of .000. The null hypothesis was rejected and the alternative hypothesis of dependency was accepted. The change in facings did decrease the number of stockout situations in the second time period.

Further analysis of the contingency table in Figure 3 indicated that no change in or increasing the number of facings led to a decrease in stockouts for 19 products. Four other products showed no change in stockouts, while one showed an increase in stockouts. Decreasing the facings available led to no change in stockouts for 15 products, an

| | | Facings: No Change Increase | Facings: Decrease | |
|---|---|---|---|---|
| Sales | No Change Increase | 14<br>13.8 | 16<br>16.2 | 30 |
| | Decrease | 9<br>9.2 | 1<br>10.8 | 20 |
| | | 23 | 27 | 50 |

Figure 1. Contingency Table Testing the Relationship of Change in Facings and Change in Sales for the Dressing Product Group

| | | Sales: No Change Increase | Sales: Decrease | |
|---|---|---|---|---|
| Stockouts | No Change Increase | 15<br>14.4 | 9<br>9.6 | 24 |
| | Decrease | 15<br>15.6 | 11<br>10.4 | 26 |
| | | 30 | 20 | 50 |

Figure 2. Contingency Table Testing the Relationship of Change in Sales and Change in Stockouts for the Dressing Product Group

increase in stockouts for 3 products and a decrease in stockouts for 8 products. Only 4 of the 50 products showed a statistically significant increase in stockouts during the posttest time period. Although sales did decline for some products, the evidence indicated that declining sales was not a likely cause of the decline in stockouts.

| | | Facings: No Change Increase | Facings: Decrease | |
|---|---|---|---|---|
| Stockouts | No Change Increase | 5<br>11.4 | 18<br>12.96 | 24 |
| | Decrease | 19<br>11.96 | 8<br>8 | 26 |
| | | 23 | 27 | 50 |

Figure 3. Contingency Table Testing the Relationship of Change in Facings and Change in Stockouts for the Dressing Product Group

Peanut Butter Product Group. Table 17 presents the results of the paired TTest for difference of means of daily sales for the peanut butter product group. Only 19 products were tested due to lack of data on the 2 products as previously discussed. The trend in sales was down overall. Seven products showed a significant decrease in sales, ten products showed no significant change and two products showed a significant increase in sales. The two with a significant increase in sales were sold at a lower than normal price for most of the posttest period.

The out of stock data by day for the product group as a whole are provided at Table 18. The paired TTest comparing the pre and posttest stockout levels showed a significant decrease in stockouts for the posttest time period. The value of T was -3.12 with a probability of a value greater than T of .005. The mean difference was -1.17 with a standard deviation of 0.37, thus fewer stockouts occurred with the shelf space reallocation.

Table 19 lists the stockout data for the individual products in the peanut butter group. Of the 19 products, 53 percent showed a decrease in stockouts, 16 percent showed no change and 26 percent showed an increase in stockouts. Both products which sold at a lower than normal price had increases in stockouts.

Contingency table analysis was not appropriate for this product group. There were not enough data points available

Table 17. Paired TTest of Daily Sales for the Peanut Butter Product Group

| Product Number | Average Diff | Std Dev | T | Prob T | Sig Diff |
|---|---|---|---|---|---|
| 1 | -4.71 | 2.09 | -2.26 | .034 | - |
| 2 | -8.74 | 3.12 | -2.72 | .015 | - |
| 3 | -0.50 | 1.02 | -0.49 | .627 | 0 |
| 4 | 0.58 | 1.03 | 0.57 | .577 | 0 |
| 5 | 37.13** | 6.69 | 5.55 | .000 | + |
| 6 | 26.00** | 3.89 | 6.68 | .000 | + |
| 7 | -2.05 | .83 | -2.47 | .024 | - |
| 8 | -5.20 | 3.79 | -1.37 | .204 | 0 |
| 9 | *** | | | | |
| 10 | -3.13 | 1.68 | -1.86 | .106 | 0 |
| 11 | -4.21 | 1.34 | -3.14 | .005 | - |
| 12 | -5.21 | 2.72 | -1.92 | .068 | 0 |
| 13 | -10.46* | 2.10 | -4.98 | .000 | - |
| 14 | 4.88 | 3.78 | -1.29 | .210 | 0 |
| 15 | -15.57* | 3.14 | -4.96 | .000 | - |
| 16 | -0.26 | .65 | -0.40 | .694 | 0 |
| 17 | -1.96 | .88 | -2.24 | .035 | - |
| 18 | 0.00 | 1.55 | 0.00 | 1.000 | 0 |
| 19 | 0.15 | 1.10 | 0.14 | .890 | 0 |
| 20 | *** | | | | |
| 21 | -0.08 | .60 | - .14 | .891 | 0 |

* = sale and extra shelf space pretest period
** = sale and extra shelf space posttest period
*** = data not available for both periods

Table 18. Out-of-Stock Data by Day for Peanut Butter Product Group

| | Pretest | | | Posttest | | |
|---|---|---|---|---|---|---|
| Day | O-o-S Snelf | O-o-S Inven | O-o-S Total | O-o-S Shelf | O-o-S Inven | O-o-S Total |
| 1 | 3 | 2 | 5 | 0 | 1 | 1 |
| 2 | 5 | 3 | 8 | 1 | 1 | 2 |
| 3 | 2 | 2 | 4 | 5 | 1 | 6 |
| 4 | 1 | 3 | 4 | 1 | 3 | 4 |
| 5 | 0 | 2 | 2 | 1 | 2 | 3 |
| 6 | 1 | 1 | 2 | 1 | 2 | 3 |
| 7 | 4 | 1 | 5 | 0 | 3 | 3 |
| 8 | 3 | 1 | 4 | 1 | 2 | 3 |
| 9 | 2 | 1 | 3 | 1 | 2 | 3 |
| 10 | 3 | 0 | 3 | 0 | 2 | 2 |
| 11 | 3 | 1 | 4 | 0 | 1 | 1 |
| 12 | 1 | 3 | 4 | 0 | 1 | 1 |
| 13 | 1 | 3 | 4 | 1 | 1 | 2 |
| 14 | 5 | 3 | 8 | 1 | 1 | 2 |
| 15 | 2 | 1 | 0 | 0 | 1 | 1 |
| 16 | 2 | 1 | 0 | 0 | 1 | 1 |
| 17 | 1 | 2 | 3 | 0 | 0 | 0 |
| 18 | 1 | 1 | 2 | 0 | 1 | 1 |
| 19 | 0 | 5 | 5 | 2 | 0 | 2 |
| 20 | 2 | 3 | 5 | 1 | 0 | 1 |
| 21 | 2 | 4 | 6 | 1 | 0 | 1 |
| 22 | 1 | 6 | 7 | 0 | 0 | 0 |
| 23 | 0 | 4 | 0 | 1 | 0 | 1 |
| 24 | 1 | 4 | 5 | 0 | 0 | 0 |

Table 19. Out-of-Stock Data for Individual Products in the Peanut Butter Product Group

| Product Number | Out-of-Stock on the Shelf: Pre Test | Out-of-Stock on the Shelf: Post Test | Change in Facings | Out-of-Stock in Inventory: Pre Test | Out-of-Stock in Inventory: Post Test |
|---|---|---|---|---|---|
| 1 | 2 | 1 | -1 | 0 | 0 |
| 2 | 4 | 0 | 0 | 3 | 0 |
| 3 | 3 | 0 | -2 | 0 | 0 |
| 4 | 0 | 1 | -3 | 0 | 0 |
| 5*** | 2 | 3 | 1 | 0 | 1 |
| 6*** | 0 | 1 | 0 | 0 | 0 |
| 7 | 3 | 0 | -1 | 5 | 0 |
| 8 | 3 | 1 | 0 | 14 | 0 |
| 9 | 8 | * | 1 | 5 | 24 |
| 10 | 4 | 0 | -1 | 16 | 0 |
| 11 | 0 | 0 | 1 | 0 | 0 |
| 12 | 0 | 1 | 1 | 0 | 0 |
| 13 | 1 | 0 | 1 | 0 | 0 |
| 14 | 5 | 1 | 2 | 0 | 0 |
| 15 | 3 | 0 | 1 | 1 | 0 |
| 16 | 2 | 3 | 0 | 1 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 |
| 18 | 4 | 3 | 0 | 6 | 1 |
| 19 | 3 | 1 | 0 | 4 | 7 |
| 20 | 0 | ** | -1 | 0 | 0 |
| 21 | 0 | 0 | -1 | 0 | 0 |

* = product out-of-stock entire period
** = product dropped and added back
*** = product priced lower than normal

to provide 5 values per cell (20:799). Other factors, such as reduced prices and new products were confounding variables that could not be accounted for in the analysis. Thus no conclusions can be drawn from the reconfiguration of facings to a 99 percent demand level for peanut butter from looking at changes within the product category.

Further analysis is provided in Figures 4 and 5. The results of the TTests for differences in daily sales showed a fairly even percentage of decreasing sales, no change in sales and increasing sales for the three product categories. Figure 5 provides similar information for for changes in stockouts for all three product groups. The cake mix product group did not show a significant change in stockouts between the two time periods. The dressing product group showed a significant decrease in stockouts, with a T of -5.93. The peanut butter product group showed a significant decrease in stockouts, with a T of -3.12. Table 5 reflects these findings, with the cake mix product indicating little change based on the frequency count. The two product groups with significant decreases in stockouts had similar frequency counts for changes in stockouts for individual products. Taken together, the tables indicate the change in sales for products in each product group were constant for all three product groups, while the decrease in stockouts were limited to the product groups that had their shelf space reallocated. The salad dressing group shows decreases

| Sales | Product Group: Cake Mix | Peanut Butter | Dressing |
|---|---|---|---|
| Decreasing | 37 | 40 | 36 |
| No Change | 60 | 54 | 53 |
| Increasing | 3 | 6 | 11 |

Figure 4. Percent Change in Sales Levels Between the Pre and Posttest Time Periods

| Stockouts | Product Group: Cake Mix | Peanut Butter | Dressing |
|---|---|---|---|
| Decreasing | 16 | 58 | 52 |
| No Change | 68 | 16 | 40 |
| Increasing | 16 | 26 | 8 |

Figure 5. Percent Change in Stockouts for Individual Products Between the Pre and Posttest Time Periods

in stockouts comparable to those of the peanut butter product group. The two groups show a different pattern with regards to increases in stockouts, however. That difference is likely to be attributed to the confounding factors associated with peanut butter: new products, lost data and special prices for some products. The next chapter will apply the results of this analysis and the statistical tests to answer the research questions and make recommendations.

# V. Conclusions and Recommendations

## Introduction

Commissary management is given direction on how much shelf space is authorized for each product group, what products may be carried in each product group, what products must be carried in each product group and what product availability or stockout rate is acceptable. Management must determine which products to carry to provide a wide selection to customers, and must allocate the shelf space to stock all products carried to ensure a 99 percent availability rate. The goals of wide product selection and high availability are sometimes conflicting, as shelf space is not available, or is not properly allocated, to stock all products to meet the 99 percent in stock goal. In several product groups, the stockout rate is higher than the one percent goal.

The objective of this research was to determine a method for allocating shelf space that would meet the required customer service levels. The affect of varying the shelf space allocation on sales and stockouts was of primary interest. The research objective was met by answering the two research questions below.

The remainder of this chapter addresses the research questions and the answers provided by the research. Recommendations are offered for a means of providing

improved service levels to commissary customers. The last section suggests future research in the area.

Research Question One

What is the impact on daily sales and stockout levels for all products in a commodity group, when the fixed amount of shelf space available is reallocated based on equalizing the products' turnover ratios?

The research indicated that changes in facings for products did not appear to affect sales of the products. The changes in facings did, however, result in a reduction in the number of stockout situations observed. An overall slight decrease in sales levels may have been considered a factor in the reduction in stockouts, but statistical analysis ruled the reduced level of sales out as a likely explanation for the improved service level available to customers.

The dressing product group's shelf space was reallocated by equalizing the turnover ratio for all products. The overall commissary sales were lower, but not significantly lower for the posttest time period. The TTest for daily sales for the dressing product group showed 40 percent of the products had a significant decrease in daily sales in the posttest time period, 54 percent had no change and 6 percent had an increase. The TTest that compared stockouts indicated a significant decrease in stockouts for the posttest time period, with a T value of -5.93. Further

tests were required to evaluate the relationship of the differences in facings, sales and stockouts. The contingency table analysis used in the previous chapter provided the test of dependency.

The contingency table analysis of the relationship between the change in facings and change in sales indicated there was not enough evidence to reject the null hypothesis of independence of the two variables. Figure 4 showed that the reduction in sales levels was approximately equal for all three product groups. This implied that the reduced level of sales of dressing was part of an overall reduced sales level, and not caused by a factor such as facings, that was different for each product group.

The contingency table analysis of the relationship between the change in facings and change in stockouts showed the two variables were dependent. Further analysis, and the results of the TTests indicated the changes in facings made during the reallocation reduced the stockout levels for most products significantly.

Research Question Two

What is the impact on daily unit sales, stockout levels and products carried when the fixed amount of shelf space available is reallocated based on providing a 99 percent in stock rate for all products?

The peanut butter product group shelf space was reallocated to provide enough units on the shelf to meet

demand 99 percent of the time. Due to changes in the product mix, to products being sold at lower than normal prices and to lack of sales data for all 21 products, the analysis was complicated, and conclusions were limited. The paired TTest for daily sales showed 7 products with a significant decrease, 10 products with no change and 2 products with an increase in sales. The paired TTest for stockouts showed a significant decrease in stockouts for the posttest time period. The decrease in sales and decrease in stockouts, coupled with the changes in product mix and sales price, made it difficult to prove a cause and affect relationship for the changes. The availability of only 19 data points precluded use of a contingency table.

A frequency count of the changes in sales and stockouts was presented in Figures 4 and 5 in the previous chapter. The changes in sales appeared to be approximately equal for all three product groups. The control group showed no significant change in stockouts, while the two reallocated product groups had significant decreases. The frequency count data can be interpreted to indicate that the reallocation of shelf space had some affect on the reduction in stockout levels. Thus, while the reallocation of shelf space to meet the 99 percent level required very little change in the number of facings for any given product, the attention given to the commodity group appears to have helped reduce the stockout situations observed.

The relationship of changes in facings to changes in sales can not be proved or disproved. Figure 4 indicated that the changes in sales were approximately equal for all product groups. This implied that the changes in sales were the result of an overall downward trend in sales, and not caused by a variable such as facings with different values for each product group.

The reallocation did not have an affect on the number of products carried. Enough shelf space was available in the product group to stock all products to the 99 percent availability level. Consequently, this method did not include the expected consequence of dropping products.

Both product groups that had their shelf space reallocated had reduced stockout levels. The equalizing turnover ratio method clearly reduced stockouts. The allocation of shelf space to meet demand 99 percent of the time could not be proven to reduce stockouts due to price changes and new products added. Both groups had improved stockout levels compared to the control group. This suggests that, although it cannot be proven, that management attention to the individual products can improve the service provided to the customer.

## Recommendations for Further Study

Based on the conclusions reached in answering the research questions, management should implement a program to reallocate shelf space based on demand for the individual

products. It appears that each product group has enough room allocated to meet 99 percent of demand, thus reallocating shelf space by equalizing turnover ratios would be the best approach. A simple spreadsheet using daily averages of sales from the CAMI report would eliminate much of the manual labor required to generate the data used in this research project, and would facilitate the changes in facings necessary to implement this reallocation plan.

An additional topic for research could be an investigation of stocking for 100 percent of daily demand and 95 percent of 2 days demand. This would allow full consideration of stocking costs as well as inventory costs. If more than one day's demand could be stocked, stockouts and labor costs might be decreased.

## Appendix A: Product Category Lists and Normalcy Test Results

Table 20. Peanut Butter Product List and Normalcy Tests for Pretest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 1 | Creamy Jiff | 18 oz. | .97 |
| 2 | Creamy Jiff | 28 oz. | .94 |
| 3 | Cruncny Jiff | 18 oz. | .92 |
| 4 | Cruncny Jiff | 28 oz. | .96 |
| 5 | Creamy Jiff | 40 oz. | .94 |
| 6 | Crunchy Jiff | 40 oz. | .95 |
| 7 | Peter Pan | 18 oz. | .96 |
| 8 | Creamy Peter Pan | 23 oz. | .96 |
| 9 | Crunchy Peter Pan | 28 oz. | .84 |
| 10 | Creamy Peter Pan | 40 oz. | .88 |
| 11 | Crunchy Peter Pan | 40 oz. | .88 |
| 12 | Chunky Skippy | 28 oz. | .89 |
| 13 | Chunky Skippy | 40 oz. | .83 |
| 14 | Creamy Skippy | 28 oz. | .98 |
| 15 | Creamy Skippy | 40 oz. | .82 |
| 16 | Creamy Skippy | 60 oz. | .93 |
| 17 | Chunky Skippy | 80 oz. | .92 |
| 18 | Creamy Smuckers | 16 oz. | .91 |
| 19 | Cruncny Smuckers | 16 oz. | .96 |
| 20 | Creamy Smuckers | 12 oz. | .92 |
| 21 | Cruncny Smuckers | 12 oz. | .92 |

Table 21. Cake Mix Product List and Normalcy Tests for Pretest Time Period

| Product Number | Product Name | Snapiro Wilkes |
|---|---|---|
| 1 | Betty Crocker Chocolate | .89 |
| 2 | Betty Crocker Yellow | .93 |
| 3 | Betty Crocker Devils Food | .92 |
| 4 | Betty Crocker Choc. Choc. Chip | .94 |
| 5 | Betty Crocker German Chocolate | .92 |
| 6 | Betty Crocker Chocolate Chip | .90 |
| 7 | Betty Crocker Cherry Chip | .95 |
| 8 | Betty Crocker Carrot | .90 |
| 9 | Betty Crocker Chocolate Almond | .86 |
| 10 | Betty Crocker Chocolate Fudge | .93 |
| 11 | Betty Crocker Carrot Two Layer | .90 |
| 12 | Betty Crocker Lemon | .91 |
| 13 | Betty Crocker Yellow Butter | .95 |
| 14 | Betty Crocker Angel Food | .90 |
| 15 | Pillsbury Yellow | .96 |
| 16 | Pillsbury German Chocolate | .94 |
| 17 | Pillsbury Devils Food | .83 |
| 18 | Pillsbury Butter | .92 |
| 19 | Duncan Hines White | .88 |
| 20 | Duncan Hines Yellow | .93 |
| 21 | Duncan Hines Devils Food | .93 |
| 22 | Duncan Hines Spice | .77 |
| 23 | Duncan Hines Fudge Marble | .91 |
| 24 | Duncan Hines Lemon | .93 |
| 25 | Duncan Hines Deep Chocolate | .95 |
| 26 | Duncan Hines Swiss Chocolate | .88 |
| 27 | Duncan Hines Butter Golden | .93 |
| 28 | Duncan Hines Butter Fudge | .94 |
| 29 | Duncan Hines Chocolate Chip | .74 |
| 30 | Duncan Hines Golden Vanilla | .95 |
| 31 | Duncan Hines Angel Food | .98 |

Table 22. Salad Dressing Product List and Normalcy Tests for Pretest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 1 | Kraft French | 16 oz. | .93 |
| 2 | Kraft Lo Cal Russian | 8 oz. | .94 |
| 3 | Kraft Buttermilk | 16 oz. | .87 |
| 4 | Kraft Ranchers Choice | 8 oz. | .93 |
| 5 | Kraft Ranchers Choice | 16 oz. | .93 |
| 6 | Kraft Lo Cal Ranchers Choice | 8 oz. | .93 |
| 7 | Kraft 1000 Island and Bacon | 8 oz. | .91 |
| 8 | Kraft Lo Cal Creamy Italian | 8 oz. | .95 |
| 9 | Kraft Zesty Italian | 8 oz. | .95 |
| 10 | Kraft Zesty Italian | 16 oz. | .96 |
| 11 | Kraft Creamy Italian | 16 oz. | .88 |
| 12 | Kraft Golden Ceaser | 8 oz. | .98 |
| 13 | Kraft Lo Cal Creamy Bacon | 8 oz. | .84 |
| 14 | Kraft Lo Cal Italian | 16 oz. | .94 |
| 15 | Kraft Lo Cal Catalina | 16 oz. | .95 |
| 16 | Kraft Catalina | 8 oz. | .98 |
| 17 | Kraft 1000 Island | 8 oz. | .97 |
| 18 | Kraft Roka Blue Cheese | 8 oz. | .94 |
| 19 | Kraft Lo Cal French | 8 oz. | .92 |
| 20 | Kraft Catalina | 16 oz. | .97 |
| 21 | Kraft Roka Blue Cheese | 16 oz. | .90 |
| 22 | Kraft 1000 Island | 16 oz. | .95 |
| 23 | Kraft Lo Cal 1000 Island | 16 oz. | .96 |
| 24 | Kraft Bacon and Tomato | 16 oz. | .96 |
| 25 | Kraft Creamy Cucumber | 16 oz. | .97 |

Table 22 (cont). Salad Dressing Product List and Normalcy Test for Pretest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 26 | Kraft Russian | 8 oz. | .91 |
| 27 | Kraft Lo Cal Cucumber | 16 oz. | .96 |
| 28 | Kraft Oil Free Italian | 8 oz. | .93 |
| 29 | Wishbone Creamy Dijon | 8 oz. | .91 |
| 30 | Wishbone Vinagrette | 8 oz. | .97 |
| 31 | Wishbone Lite Vinagrette | 8 oz. | .94 |
| 32 | Wishbone Lite Creamy Dijon | 8 oz. | .95 |
| 33 | Wishbone Chunky Blue Cheese | 8 oz. | .91 |
| 34 | Wisnbone Lite Blue Cheese | 8 oz. | .96 |
| 35 | Wishbone Italian | 16 oz. | .92 |
| 36 | Wisnbone Robusto Italian | 16 oz. | .96 |
| 37 | Wishbone Russian | 8 oz. | .93 |
| 38 | Wishbone French | 16 oz. | .97 |
| 39 | Wishbone French | 8 oz. | .92 |
| 40 | Wisnbone Lite French | 16 oz. | .97 |
| 41 | Wishbone Lte Italian | 8 oz. | .97 |
| 42 | Wishbone Lite French | 8 oz. | .91 |
| 43 | Wishbone Lite Russian | 8 oz. | .96 |
| 44 | Wisnbone 1000 Island | 8 oz. | .87 |
| 45 | Marzetti Slaw Dressing | | .91 |
| 46 | Hidden Valley Creamy | 8 oz. | .89 |
| 47 | Hidden Valley Creamy | 16 oz. | .93 |
| 48 | Hidden Valley Herb | 8 oz. | .93 |
| 49 | Hidden Valley 1000 Island | 8 oz. | .94 |
| 50 | Hidden Valley Creamy Bacon | 8 oz. | .95 |

Table 23. Peanut Butter Product List and Normalcy Tests for Posttest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 1 | Creamy Jiff | 18 oz. | .88 |
| 2 | Creamy Jiff | 28 oz. | .94 |
| 3 | Crunchy Jiff | 18 oz. | .92 |
| 4 | Crunchy Jiff | 28 oz. | .84 |
| 5 | Creamy Jiff | 40 oz. | .93 |
| 6 | Crunchy Jiff | 40 oz. | .95 |
| 7 | Peter Pan | 18 oz. | .87 |
| 8 | Creamy Peter Pan | 28 oz. | .91 |
| 9 | Crunchy Peter Pan | 28 oz. | * |
| 10 | Creamy Peter Pan | 40 oz. | .94 |
| 11 | Crunchy Peter Pan | 40 oz. | .95 |
| 12 | Chunky Skippy | 28 oz. | .90 |
| 13 | Chunky Skippy | 40 oz. | .91 |
| 14 | Creamy Skippy | 28 oz. | .96 |
| 15 | Creamy Skippy | 40 oz. | .92 |
| 16 | Creamy Skippy | 80 oz. | .96 |
| 17 | Chunky Skippy | 80 oz. | .89 |
| 18 | Creamy Smuckers | 16 oz. | .96 |
| 19 | Crunchy Smuckers | 16 oz. | .95 |
| 20 | Creamy Smuckers | 12 oz. | ** |
| 21 | Crunchy Smuckers | 12 oz. | .93 |

* = product out-of-stock entire period
** = sales data not accumulated by ACOS

Table 24. Cake Mix Product List and Normalcy Tests for Posttest Time Period

| Product Number | Product Name | Shapiro Wilkes |
|---|---|---|
| 1 | Betty Crocker Chocolate | .92 |
| 2 | Betty Crocker Yellow | .97 |
| 3 | Betty Crocker Devils Food | .92 |
| 4 | Betty Crocker Choc. Choc. Chip | .76 |
| 5 | Betty Crocker German Chocolate | .91 |
| 6 | Betty Crocker Chocolate Chip | .90 |
| 7 | Betty Crocker Cherry Chip | .92 |
| 8 | Betty Crocker Carrot | .93 |
| 9 | Betty Crocker Chocolate Almond | .84 |
| 10 | Betty Crocker Chocolate Fudge | .94 |
| 11 | Betty Crocker Carrot Two Layer | .93 |
| 12 | Betty Crocker Lemon | .95 |
| 13 | Betty Crocker Yellow Butter | .87 |
| 14 | Betty Crocker Angel Food | .95 |
| 15 | Pillsbury Yellow | .95 |
| 16 | Pillsbury German Chocolate | .93 |
| 17 | Pillsbury Devils Food | .89 |
| 18 | Pillsbury Butter | .89 |
| 19 | Duncan Hines White | .93 |
| 20 | Duncan Hines Yellow | .93 |
| 21 | Duncan Hines Devils Food | .92 |
| 22 | Duncan Hines Spice | .78 |
| 23 | Duncan Hines Fudge Marble | .94 |
| 24 | Duncan Hines Lemon | .93 |
| 25 | Duncan Hines Deep Chocolate | .93 |
| 26 | Duncan Hines Swiss Chocolate | .97 |
| 27 | Duncan Hines Butter Golden | .94 |
| 28 | Duncan Hines Butter Fudge | .90 |
| 29 | Duncan Hines Chocolate Chip | .80 |
| 30 | Duncan Hines Golden Vanilla | .92 |
| 31 | Duncan Hines Angel Food | .94 |

Table 25. Salad Dressing Product List and Normalcy Tests for Posttest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 1 | Kraft French | 16 oz. | .93 |
| 2 | Kraft Lo Cal Russian | 8 oz. | .85 |
| 3 | Kraft Buttermilk | 16 oz. | .97 |
| 4 | Kraft Ranchers Choice | 8 oz. | .95 |
| 5 | Kraft Ranchers Choice | 16 oz. | .93 |
| 6 | Kraft Lo Cal Ranchers Choice | 8 oz. | .97 |
| 7 | Kraft 1000 Island and Bacon | 8 oz. | .96 |
| 8 | Kraft Lo Cal Creamy Italian | 8 oz. | .95 |
| 9 | Kraft Zesty Italian | 8 oz. | .94 |
| 10 | Kraft Zesty Italian | 16 oz. | .95 |
| 11 | Kraft Creamy Italian | 16 oz. | .98 |
| 12 | Kraft Golden Ceaser | 8 oz. | .96 |
| 13 | Kraft Lo Cal Creamy Bacon | 8 oz. | .88 |
| 14 | Kraft Lo Cal Italian | 16 oz. | .96 |
| 15 | Kraft Lo Cal Catalina | 16 oz. | .94 |
| 16 | Kraft Catalina | 8 oz. | .97 |
| 17 | Kraft 1000 Island | 8 oz. | .94 |
| 18 | Kraft Roka Blue Cheese | 8 oz. | .95 |
| 19 | Kraft Lo Cal French | 8 oz. | .96 |
| 20 | Kraft Catalina | 16 oz. | .87 |
| 21 | Kraft Roka Blue Cheese | 16 oz. | .92 |
| 22 | Kraft 1000 Island | 16 oz. | .94 |
| 23 | Kraft Lo Cal 1000 Island | 16 oz. | .97 |
| 24 | Kraft Bacon and Tomato | 16 oz. | .87 |
| 25 | Kraft Creamy Cucumber | 16 oz. | .95 |

Table 25 (cont). Salad Dressing Product List and Normalcy Test for Posttest Time Period

| Product Number | Product Name | | Shapiro Wilkes |
|---|---|---|---|
| 26 | Kraft Russian | 8 oz. | .90 |
| 27 | Kraft Lo Cal Cucumber | 16 oz. | .96 |
| 28 | Kraft Oil Free Italian | 8 oz. | .91 |
| 29 | Wishbone Creamy Dijon | 8 oz. | .87 |
| 30 | Wishbone Vinagrette | 8 oz. | .95 |
| 31 | Wishbone Lite Vinagrette | 8 oz. | .98 |
| 32 | Wishbone Lite Creamy Dijon | 8 oz. | .98 |
| 33 | Wishbone Chunky Blue Cheese | 8 oz. | .96 |
| 34 | Wishbone Lite Blue Cheese | 8 oz. | .98 |
| 35 | Wishbone Italian | 16 oz. | .96 |
| 36 | Wishbone Robusto Italian | 16 oz. | .92 |
| 37 | Wishbone Russian | 8 oz. | .91 |
| 38 | Wishbone French | 16 oz. | .94 |
| 39 | Wishbone French | 8 oz. | .91 |
| 40 | Wishbone Lite French | 16 oz. | .88 |
| 41 | Wishbone Lte Italian | 8 oz. | .93 |
| 42 | Wishbone Lite French | 8 oz. | .96 |
| 43 | Wisnbone Lite Russian | 8 oz. | .92 |
| 44 | Wishbone 1000 Island | 8 oz. | .96 |
| 45 | Marzetti Slaw Dressing | | .95 |
| 46 | Hidden Valley Creamy | 8 oz. | .95 |
| 47 | Hidden Valley Creamy | 16 oz. | .94 |
| 48 | Hidden Valley Herb | 8 oz. | .95 |
| 49 | Hidden Valley 1000 Island | 8 oz. | .86 |
| 50 | Hidden Valley Creamy Bacon | 8 oz. | .92 |

## Appendix B: Additional Data Comparisons for Pre and Posttest Time Periods

### Table 26. Daily Sales Data for Commissary Grocery Department for Pre and Posttest Periods

| Day | Pretest ($) | Posttest ($) |
|---|---|---|
| 1 | 148,690.32 | 122,235.75 |
| 2 | 142,002.07 | 116,593.84 |
| 3 | 143,810.48 | 148,334.92 |
| 4 | 125,717.19 | 111,672.89 |
| 5 | 139,101.32 | 121,281.87 |
| 6 | 81,640.35 | 65,060.92 |
| 7 | 127,530.55 | 109,477.94 |
| 8 | 117,053.70 | 98,255.85 |
| 9 | 145,591.53 | 122,748.11 |
| 10 | 114,714.27 | 89,378.41 |
| 11 | 114,705.16 | 98,459.52 |
| 12 | 57,517.11 | 57,110.26 |
| 13 | 107,170.25 | 106,984.66 |
| 14 | 102,254.31 | 95,982.42 |
| 15 | 134,540.29 | 153,216.18 |
| 16 | 108,905.20 | 121,712.93 |
| 17 | 127,228.77 | 124,553.64 |
| 18 | 69,188.05 | 74,583.89 |
| 19 | 97,164.24 | 129,668.71 |
| 20 | 92,618.18 | 117,050.82 |
| 21 | 115,288.46 | 139,599.33 |
| 22 | 99,237.12 | 102,251.05 |
| 23 | 108,330.04 | 108,578.75 |
| 24 | 65,445.36 | 58,992.24 |

Table 27. Differences in Sales, Out-of-Stock and Facings Between Time Periods for the Dressing Product Group

| Product Number | Diff*. in Sales | Diff. in O-o-S | Diff. in Facings |
|---|---|---|---|
| 1 | + | 0 | - |
| 2 | 0 | - | - |
| 3 | 0 | 0 | 0 |
| 4 | - | - | - |
| 5 | 0 | - | + |
| 6 | 0 | - | + |
| 7 | - | 0 | - |
| 8 | - | 0 | 0 |
| 9 | 0 | - | + |
| 10 | - | - | + |
| 11 | - | - | 0 |
| 12 | 0 | - | - |
| 13 | - | - | 0 |
| 14 | 0 | - | + |
| 15 | - | - | + |
| 16 | 0 | 0 | - |
| 17 | - | 0 | - |
| 18 | 0 | 0 | - |
| 19 | 0 | 0 | - |
| 20 | 0 | 0 | + |
| 21 | 0 | - | + |
| 22 | + | 0 | - |
| 23 | - | - | + |
| 24 | 0 | - | - |
| 25 | - | - | - |

* = difference is posttest - pretest
- indicates a decrease in sales, stockouts or facings in the posttest time period
0 indicates no difference betwen periods
+ indicates an increase in the posttest time period

Table 27 (cont). Differences in Sales, Out-of-Stock and Facings Between Time Periods for the Dressing Product Group

| Product Numoer | Diff*. in Sales | Diff. in O-o-S | Diff. in Facings |
|---|---|---|---|
| 26 | 0 | 0 | - |
| 27 | 0 | - | 0 |
| 28 | - | - | + |
| 29 | 0 | 0 | - |
| 30 | - | - | - |
| 31 | 0 | - | + |
| 32 | - | 0 | - |
| 33 | - | - | - |
| 34 | 0 | - | + |
| 35 | 0 | - | + |
| 36 | 0 | - | 0 |
| 37 | - | 0 | - |
| 38 | 0 | 0 | - |
| 39 | - | + | - |
| 40 | 0 | + | - |
| 41 | - | - | 0 |
| 42 | 0 | 0 | - |
| 43 | 0 | - | - |
| 44 | 0 | 0 | - |
| 45 | 0 | - | 0 |
| 46 | + | 0 | + |
| 47 | - | + | + |
| 48 | - | 0 | - |
| 49 | 0 | 0 | - |
| 50 | - | + | - |

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Major Michael J. Peterson graduated from the University of Maine in 1975 with a Bachelor of arts Degree in Political Science. Later graduate study with the University of Utah led to a Masters Degree in Business Administration in 1981.

Commissioned in 1974 through Officer Training School, he completed navigator and electronic warfare officer training at Mather Air Force Base, California. His first two assignments were as an instructor electronic warfare officer with Special Operations squadrons in Germany and Florida. These were followed by an assignment to the initial cadre of the EC-130H Compass Call unit in Tucson, Arizona, where duties included instructor and flight examiner mission crew commander and unit plans officer. This led to an assignment at intermediate command level as Chief of the EC-130 Requirements and Operations Branch. He entered the School of Systems and Logistics, Air Force Institute of Technology in May 1986.

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Thesis Chairman: Larry W. Emmelhainz, Major, USAF
Associate Professor of Logistics Management

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Block 19. ABSTRACT

The purpose of this research was to analyze shelf space allocation at the Wright-Patterson Air Force Base Commissary. The commissary had a product in stock goal of 99 percent, which was not being met for all products. The research addressed two different methods of shelf space allocation, within existing constraints of product mix and shelf space available, to limit out-of-stock situations.

The study was accomplished by an experiment thay used an initial data collection period to establish a baseline of sales and stockouts for three product groups. Shelf space was reallocated for 2 product groups by equalizing the turnover ratios of products for 1 group, and by stocking to meet 99 percent of demand for the products for the other product group. After a posttest data collection period, comparisons were made using paired TTests to compare pre and posttest sales and atockouts for products in all three product groups. A Chi Square test was used to test the relationship between changes in product level stocked, sales and stockouts.

It was concluded that the extra attention paid to the two reallocated product groups led to a reduction in the number of stockouts observed. Equalizing turnover ratios significantly reduced the number of stockouts, while not appearing to affect the sales levels of individual products. Due to confounding factors, statistical tests were not valid for the reallocation of shelf space to meet 99 percent of demand. The results showed a significant decrease in stockouts, but a cause could not be proved.

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