# The effectiveness of multiple delivery strategies in relation to retail apparel assortments

by

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# ABSTRACT

The objectives of this study were to: 1) propose a model of merchandise replenishment process set in the context of Behavioral Theory of the Apparel Firm with quick response business systems, and 2) evaluate the performance of multiple delivery strategies in relation to volume per stock keeping unit (SKU) for the assortment for two selling periods by using the apparel retail model (ARM) computer simulation. Based on the literature review, the study defined the merchandise replenishment process, developed a model of merchandise replenishment process, and proposed a concept of volume per SKU for the initial delivery (VSID). Data were generated using ARM computer simulation and were statistically analyzed. Two performance measures and quantitative guidelines for developing delivery strategies were developed. Results confirmed 4 elements of the proposed model, identified that the higher the VSID the fewer additional deliveries required to get better performance than single delivery, and indicated that multiple delivery strategies did not improve overall performance for fashion and seasonal goods with a 10 week selling period. Implications for merchandising strategies were described. Future research directions were provided.

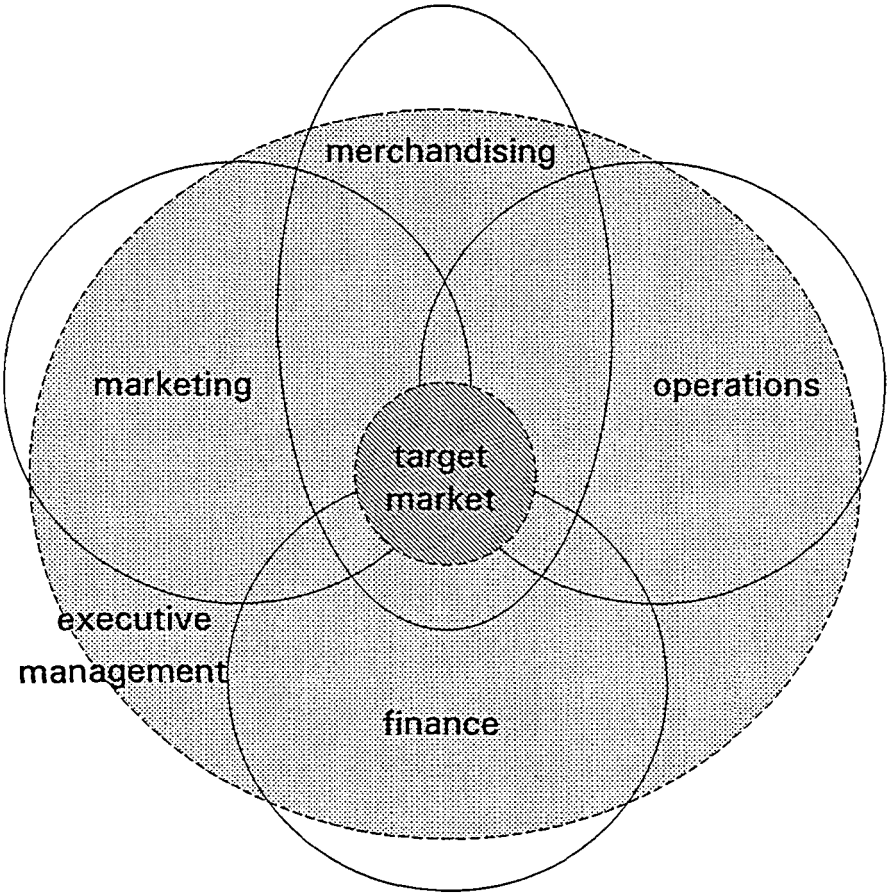
# INTRODUCTION

Quick response (QR) is the apparel industry's main effort to help domestic firms compete in global and domestic markets. The benefits of QR include fewer stockouts, higher stock turnover, and reduced markdowns (Hammond, 1993; Hunter, 1990; Nuttle, King, & Hunter, 1992). These benefits lead to increased sales (Hunter, 1990; Lewison, 1991; "Measuring the impact," 1991; Setren, 1993) and reduced expenses related to merchandising, distribution, and administration (Gilman, 1989; "Measuring the impact," 1991). In order to realize these benefits, retail firms must change their corporate culture, operating procedures, and technological base (Hammond, 1993; Nuttle, King, & Hunter, 1992).

Some of these changes relate to merchandising (Kunz, 1995). Merchandising is the process of "planning, development, and presentation of product line(s) for identified target market(s) with regard to prices, assortments, styling, and timing" (Glock & Kunz, 1995, p. 63). Examples of changes related to merchandising are cooperatively planning assortments with suppliers (Buzzell & Ortmeyer, 1995; Hammond, 1993; Nuttle, King, & Hunter, 1992), planning assortments and managing inventory at full stock keeping unit (SKU) level at individual stores, and placing smaller initial orders and replenishing merchandise based on point-of-sale (POS) data (Hammond, 1993; Nuttle, King, & Hunter, 1991; 1992).

In order to reflect the changing nature of the apparel industry and the importance of the merchandising constituency, Kunz (1995) proposed the Behavioral Theory of the Apparel Firm as a framework for apparel business related research. According to Kunz's (1995) behavioral theory, an apparel firm includes five constituencies: merchandising, marketing, operations, finance, executive management (Figure 1). This model describes the purposes of each constituency, the interactions among them, and their relationships to external organizations.

The major responsibility of a merchandising constituency is to plan, develop, and present apparel product lines that provide the firm's primary source of income (Kunz, 1995). The merchandising constituency analyzes customers' apparel preferences, interprets target customers' needs to the rest of the firm, and makes decisions related to product lines to




| Constituency | Responsibility |
|---|---|
| Executive | establishes the firm's goals and administers activities to achieve them |
| Merchandising | plans, develops, and presents product lines |
| Marketing | define target customer(s) and develops positioning and promotion strategies |
| Operations | manages people and physical property |
| Finance | manages financial resources |

Figure 1. The responsibilities of constituencies within an apparel firm and their interaction (Kunz, 1995, p. 255, 257).

satisfy customer needs. These decisions are based on the input from the rest of the firm and the economic, social, cultural environmental factors of the firm. Negotiation is used to resolve conflicts among internal constituencies and with external organizations (Kunz, 1995).

Merchandise planning is the foundation of developing and presenting product lines that satisfy customer demand and meet merchandising goals (Glock & Kunz, 1995; Kunz, 1996; Mason, Mayor, & Ezell, 1994; Robins, 1989). Assortment planning is part of merchandise planning. The major decision factors of assortment planning include determining the number of SKUs, volume, distribution of volume in each SKU, and timing of merchandise presentation (Rupe & Kunz, in review). Few guidelines are available to help merchandisers determine successful merchandise assortments (Rupe & Kunz, in review). Traditionally, the decisions related to these factors are highly dependent upon the judgment, intuition, and experience of merchandisers (Trappey, 1992).

Computer simulation is another way of estimating the performance of assortment planning (Hunter, King, & Nuttle, 1991; Nuttle, King, & Hunter, 1991; 1992). Primary advantages of using computer simulations are saving time and money and making more accurate plans (Hunter, King, & Nuttle, 1991; King & Poindexter, 1991; Levy, 1990).

Apparel Retail Model (ARM), developed by Hunter, King, and Nuttle (1991), is an interactive computer simulation model for apparel merchandising. Its objective was to speed up the adoption of QR for seasonal and fashion merchandise (King & Poindexter, 1991; Nuttle, King, & Hunter, 1991). This simulation model allows merchandisers to control the influence of extraneous variables involved in determining financial outcomes, to input various apparel scenarios, and to analyze their performance. It can help merchandisers evaluate the effectiveness of assortment, pricing, and delivery strategies (King & Poindexter, 1991; Nuttle, King, & Hunter, 1991; Rupe and Kunz, in review).

Using ARM as a research tool, Rupe and Kunz (in review) proposed the concept of a volume per SKU for the assortment (VSA) as a means of reducing uncertainty related to assortment planning and helping merchandisers develop assortment strategies. VSA is a measure that indicates the number of units allocated, on the average, for each SKU in a given assortment. Based on single delivery, they found that the lower the VSA the lower the

financial performance. They suggested several additional research topics that would further develop the concept of VSA including using ARM to test the financial performance of multiple delivery strategies in relation to VSA.

According to ARM, multiple delivery means an initial delivery and several additional deliveries based on re-estimation of POS data (Nuttle, King, & Hunter, 1991; Hunter, King, & Nuttle, 1992). The purpose of developing multiple delivery strategies is to help retailers order in smaller quantities on a more frequent basis to reduce inventory investment, stockouts, markdowns, and improve salability. The primary decision elements of multiple delivery strategies involve the number of deliveries, the quantity of each delivery, and the timing of additional deliveries. Their advantage compared to single delivery is to more accurately accommodate customer preferences. Their disadvantages are increased costs of merchandise order processing, handling, and transportation.

Multiple delivery strategies have been extensively applied to basic and staple goods (Kunz, 1996; Nuttle, King, & Hunter, 1991). The research and practical execution of multiple delivery strategies on seasonal and fashion goods is limited (Irastorza, 1992; Kunz, 1996). The purposes of this study are to examine whether multiple delivery strategies can apply to fashion and seasonal goods and to evaluate the performance of multiple delivery strategies in relation to VSA. Ten and 20 week selling periods were used to represent fashion and seasonal goods.

This study is part of the Ramal project, directed by Dr. Grace Kunz. Ramal is a code name for the midwest based, upscale, apparel specialty retailer that is the business collaborator for the project. The Ramal project involves four research topics including studying in-store shopping behavior in relation to stockouts, examining the relationship of assortment diversity and potential financial productivity, exploring price elasticity as related to fashion and basic goods, and, this study, evaluating the performance of multiple delivery strategies in relation to assortment diversity.

## Objectives

1. Propose a model of merchandise replenishment process set in the context of Behavioral Theory of the Apparel Firm.
2. Evaluate the performance of multiple delivery strategies in relation to VSA for two selling periods by using the ARM simulation.

## Assumptions

1. ARM is a useful means of assessment of multiple delivery strategies.
2. Better delivery strategies will improve firms performance.
3. Computer simulated outcomes can be applied to real world retailers.

## Limitations

1. ARM is an abstraction of reality and outcomes may not represent all apparel assortment planning scenarios.
2. The shortest lead time allowed by ARM is 1 week.
3. The longest selling period allowed by ARM is 20 weeks.

## Definitions

1. Assortment diversity: "the range of relationships that can exist between assortment volume and number of SKUs in an assortment" (Rupe & Kunz, in review, p. 14).
2. Assortment factors: style, size, and color (or other factors depending on the merchandise classifications) (Rupe & Kunz, in review).
3. Average inventory: the average number of units in stock during the selling period (Poindexter, 1991).
4. Basic goods: "classifications that experience little demand for change in styling from one merchandising cycle to the next" (Kunz, 1996, p. 14).
5. Fashion goods: "classifications that experience frequent demand for change in styling during a merchandising cycle" (Kunz, 1996, p. 14).
6. Frequency of additional deliveries (FAD): the number of additional deliveries in a selling periods.
7. Gross margin (GM): a financial term that expresses the dollar difference between net sales and costs of merchandise sold.

8. Gross margin return on inventory (GMROI): The financial ratio that shows the relationship between the gross margin in dollars and the average inventory investment.
9. Initial order: a request to receive merchandise not previously stocked.
10. Lead time: the time between placing the initial order or reorder(s) and receiving the merchandise on the retail sales floor.
11. Merchandise classification: "group of products that are reasonable substitutes for each other from the perspective of customers; similar in function, selling period, and price" (Kunz, 1996, p. 14).
12. Merchandise replenishment: the process of planning and placing reorders, as well as handling, shipping, receiving, distributing if necessary, and displaying merchandise.
13. Merchandising cycle: "One year period from February 1 to January 31" (Kunz, 1996, p. 14).
14. Multiple delivery: using more than one shipment of a given merchandise assortment based on an initial order and reorder(s).
15. Order: a request to receive merchandise
16. Performance measures: the indicators which help a firm judge the efficiency and effectiveness of their strategies.
17. Quick response merchandise replenishment: a customer driven process of planning and placing reorders, as well as handling, shipping, receiving, distributing if necessary, and displaying merchandise with the shortest possible lead time.
18. Reorder: a request to replenish merchandise previously stocked.
19. Seasonal goods: "classifications that experience changes in market demand during a merchandising cycle related to ethnic and cultural events, holidays, and weather change" (Kunz, 1996, p. 14).
20. Selling period: weeks during merchandising cycle when products are salable.
21. Single delivery: shipment of 100% of a given merchandise assortment based on an initial order.
22. Staple goods: "classifications that are in continuous demand throughout a merchandising cycle; demand is not greatly affected by the time of the year" (Kunz, 1996, p. 14).

23. Stock keeping unit (SKU): an unique item in an apparel assortment identified by a combination of assortment factors (Glock & Kunz, 1995).
24. Stock turnover: the number of times the average stock is sold within a given period of time.
25. Stockout: the particular SKU desired by the customer is not immediately available (Kunz & Song, in review).
26. Volume per SKU for the assortment (VSA): the average number of units per SKU for a given assortment (Rupe & Kunz, in review).
27. Volume per SKU for the initial delivery (VSID): the number of units allocated on the average for each SKU in the initial delivery.
28. Volume: "total number of units in an assortment" (Rupe & Kunz, in review, p.16).

# REVIEW OF LITERATURE

Two areas of literature were reviewed to understand multiple delivery strategies in relation to retail apparel assortments. The first part of the literature review explains the meaning of Quick Response (QR) and its relationship to Behavioral Theory of the Apparel Firm (Kunz, 1995). The second part of the literature review describes the concepts of merchandise planning and its relationship to multiple delivery strategies.

## Quick Response

The formation of QR movement for textiles and apparel originated from Crafted With Pride (CWP) in 1984 because of increasing imports and competition from the Far East (Hunter, 1990; Hunter, King, & Nuttle, 1991). The original thinking was that the competitive advantage of geographic proximity would enable domestic retailers and manufacturers to satisfy U.S. customers' demands with a speed not possible for distant, offshore competitors (Blackburn, 1991; Abend, 1987). QR has been recognized as a key to survival in the U. S. and foreign market (King & Poindexter, 1991).

However, there is no common and clear definition of QR although the concept has been developing for more than 10 years. Most definitions of QR have been based on its benefits or the usage of sophisticated technology to simplify the operating process (Kunz & Rupe, 1995). Kunz (1996) examined QR research and trade literature and defined QR as "a comprehensive business strategy incorporating time-based competition, agility, and partnering to optimize the supply system, the distribution system, and service to customers" (p. 3). In other words, QR emphasizes the importance of timing, flexibility, and human relationships in and among firms. Any method of shortening the time for operating procedures, increasing the response speed in the supply and distribution system, and improving the service level to customers can be considered part of QR strategies.

QR is a customer-driven strategy (Blackburn, 1991). The overall objective of QR is to respond to customer's demands and optimize the firm's goals. It is a pull-through system instead of traditional push-through system (Blackburn, 1991; Glock & Kunz, 1995; Kunz, 1996). In the traditional push-through system, manufacturers and retailers make what is convenient and offer assortments they believe customers will buy (Glock & Kunz, 1995;

Troxell, 1976). In contrast, a pull-through system lets customers decide what they want. Product capability and merchandise offered is adjusted to respond to customer demand based on point of sales (POS) information and styling testing (Glock & Kunz, 1995). In order to further understand the meaning of QR, the following concepts are presented in three parts based on the Kunz (1996) QR definition.

**Time-based competition**

Time is regarded as a firm's primary competitive resource (Blackburn, 1991). Shortening the cycle time of the entire soft goods production and distribution process helps textile, apparel, and retail firms to acquire competitive advantages. Quick decisions made closer to the time of sale in response to actual customer demand can be more accurate and consequently more profitable (Blackburn, 1991; Hunter, 1990; Kunz, 1996).

The process of converting raw materials to apparel includes both a product flow from the suppliers to the retailers and an information flow from the retailers to the suppliers (Blackburn, 1991) (Figure 2). Product flows forward from textile producers to customers in value-added processes. Information flows backward from customers to apparel and textile manufacturers by using electronic data interchange (EDI) (Blackburn, 1991).

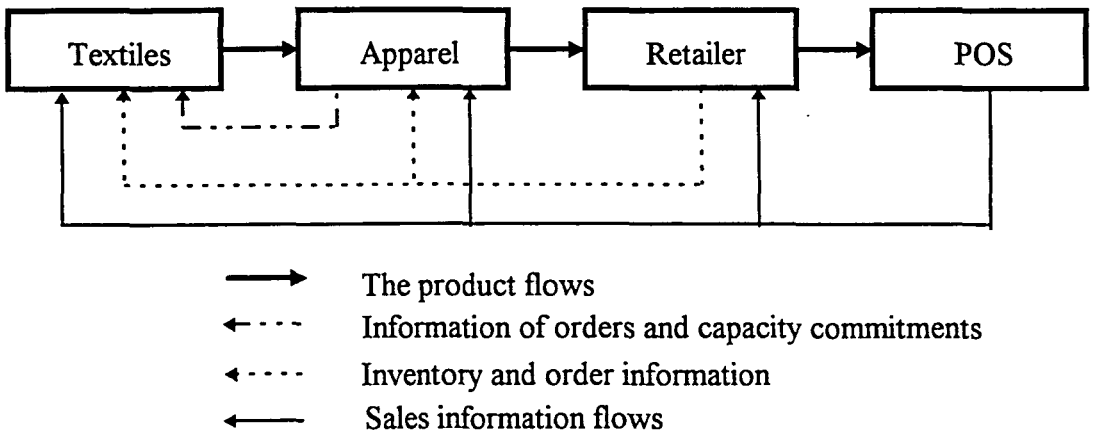



Figure 2. Product and information flows in the apparel chain (Blackburn, 1991).

Conventional approaches to shorten the cycle time of the entire apparel chain from fiber production to the retail sales floor emphasize speeding product flows through the pipeline. QR strategies pay attention to speeding not only product flows but also information flows (Blackburn, 1991; "Quick response technologies," 1991). The methods used to speed both flows include changing operating procedures, using technologies, and developing cooperative partnerships (Blackburn, 1991, Glock & Kunz, 1995; Hammond, 1993).

In terms of changing operating procedures, Buzzell and Ortmeyer (1995) identified four key issues: 1) using information technologies to automate manual activities, 2) eliminating redundancies in operating procedures, 3) reassigning tasks for maximum apparel chain efficiency, and 4) reducing or eliminating control steps in operating procedures.

In terms of using technologies, benefits include improving the response time of transmitting customer preferences back to all members of the apparel chain (Blackburn, 1991; "EDI," 1991); reducing the amount of paper work and data entry for both vendors and retailers, improving the efficiency of creating, communicating and tracking purchase orders (Gilman, 1989; "Measuring the impact," 1991); and increasing the efficiency and effectiveness of merchandising, producing, and distributing (Buzzell & Ortmeyer, 1995; Hammond, 1993; Kunz & Rupe, 1995).

EDI, bar coding, and scanning are the most common QR technologies used to support time-based competition in retailing. EDI is computer-to-computer communication. It uses the direct computer to computer exchange of business information between venders and customers in a standard electronic format without any human intervention (Baker, 1991; "Quick response technologies," 1991). The information exchanged by computers may include product catalogs, product planning schedules, sales, purchase orders, advance ship notices, invoices, functional acknowledgment, and capacity commitments (Blackburn, 1991; Gordon, 1993; Gray, 1993; "Quick response technologies," 1991).

Bar coding, used in conjunction with scanning devices, facilitate merchandise tracking and inventory control at the SKU level because all relevant information for each product may be automatically captured by scanning bar codes (Hammond, 1993; Gilman, 1989; "Measuring the impact," 1991). Universal product code (UPC) and shipping container marking (SCM)

are the two important bar coding systems for retail firms. UPC is the dominant bar coding system used at POS (Hammond, 1993; "Quick response technologies," 1991). UPC is a 12-digit merchandise code including a 5-digit vendor number, a 5-digit merchandise number, and leading and trailing digits. This code is scanned and translated by an optical scanning device at POS when a customer makes a purchase (Hammond, 1993). POS information helps firms to analyze customer preferences, forecast sales trends, make future decisions on reorders and new product introductions, manage inventory, and speed customer flow at checkout (Kunz & Rupe, in review).

SCM increases the speed and accuracy of merchandise distribution processes (Hammond, 1993). SCM supplied by the manufacturer provides information on vendors, orders, destinations, and carton numbers for each shipping carton. This information allows containers to be received, verified and sent to the sales floor without being opened (Hammond, 1993; "Quick response technologies," 1991). By pre-ticketing merchandise with UPC and cartons with SCM, retailers may reduce the labor force handling merchandise and accelerate the flow of merchandise through the distribution center (Gilman, 1989). Shipments may flow constantly and consistently and merchandise may be re-stocked directly from the manufacturer to the sales floor (Setren, 1993).

**Agility**

A firm's agility helps it thrive in a rapidly changing, fragmented market (Goldman, Nagel, & Preiss, 1995). Agility is the firms' ability to make information driven decisions at the latest possible moment depending on the flexibility of supply, production, and distribution systems (Fralix, & Off, 1993; 1994; Kunz, 1996).

Flexible manufacturing is a prerequisite of agility (Sheridan, 1994). Flexible manufacturing is the capability of apparel and textile manufacturers "to quickly and efficiently produce a variety of styles in small production runs with no defects" (Glock & Kunz, 1995, p. 310). The objectives of flexible manufacturing are to quickly produce products customers request and deliver them to the retail sales floor without having to stock excessive inventory. To achieve flexible manufacturing one must share information among business partners, use technologies to speed the efficiency of product development and communication, and

continuously train employees to be knowledgeable, skilled, flexible workforces (Fralix, & Off, 1993; 1994).

**Partnerships**

Cultivating cooperative partnerships among colleagues, constituencies of a firm, and business partners is the cornerstone of QR (Blackburn, 1991; Glock & Kunz, 1995; Sheridan, 1994). By creating closer working partnerships, manufacturers of materials and apparel as well as retailers can fundamentally modify the processes of merchandising and distribution (Buzzell & Ortmeyer, 1995); share information about sales, orders, and inventory; and coordinate their activities to quickly meet the actual demands of ultimate customers (Blackburn, 1991).

Traditionally, the characteristics of apparel firms involved short-term focus, adversarial inter-firm relationships, lack of attention to human resources, and lack of flexibility in production (Hammond, 1993). In order to effectively develop cooperative partnerships, firms need to change their organizational structures, strategies, reporting relationships, management style, and communication methods (Buzzell & Ortmeyer, 1995; Hammond, 1993; Rauh, 1994). Two changes related to communication methods are providing adequate communication and training for employees related to operating technologies and procedures (Fralix, & Off, 1993; 1994; "Ten steps," 1991) and understanding each other's business objectives, opportunities, and constraints ("Quick response," 1991). In a cooperative relationship, vendors are less likely to push large quantities of goods on retailers or produce and ship merchandise at the last-minute. Retailers less likely to play games with delivery dates and ask for special ticketing or handling (Setren, 1993; "Ten steps," 1991).

**Relationship to Behavioral Theory of the Apparel Firm**

In order to reflect the influence of QR on the apparel industry, Kunz (1996) has incorporated the concepts of QR into the Behavioral Theory of the Apparel Firm and modified Kunz's (1995) behavioral theory model with a QR construct (Figure 3). The thickness of the QR construct represents the level of an apparel firm involvement in the QR systems.

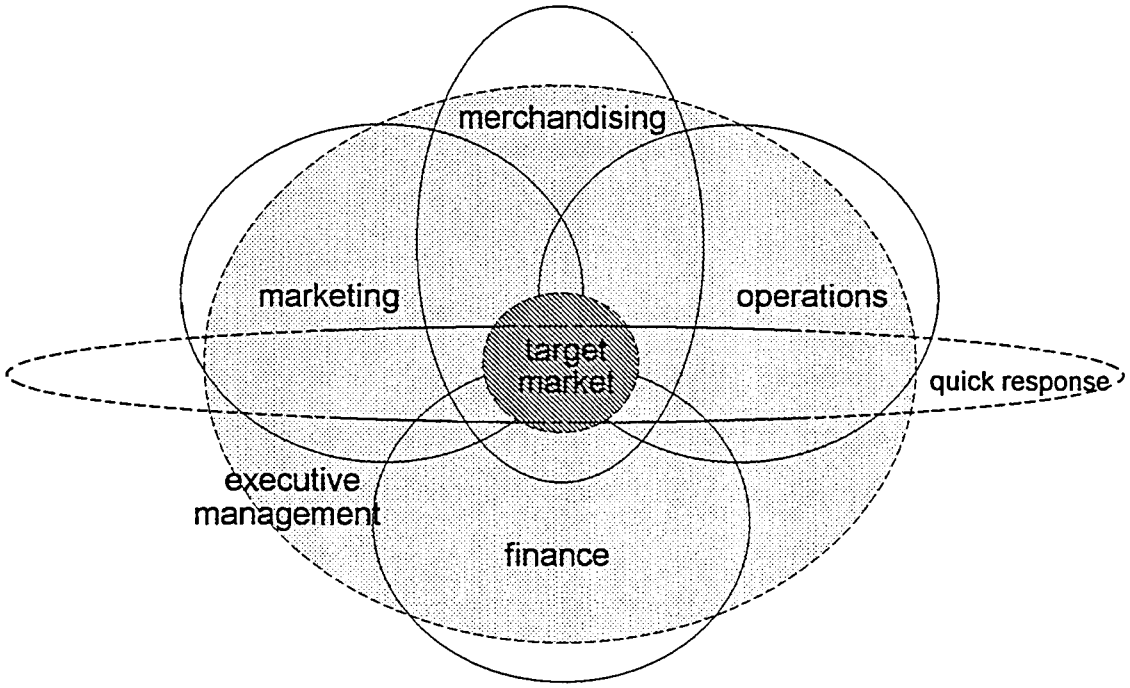



Figure 3. Interaction of the functional areas of specialization of an apparel firm operating with quick response systems (Kunz, 1996, p. 16).

## Merchandise Planning

Effective merchandise planning is essential to establishing a competitive advantage in the market (Mason, Mayor, & Ezell, 1994; Glock & Kunz, 1995). The principal components of merchandise planning are evaluating merchandise classifications and performance of past seasons, synthesizing current fashion trends and socioeconomic issues, as well as developing merchandise budgets and assortment plans for the coming season (Glock & Kunz, 1995, Kunz, 1996). The primary objective of merchandise planning is to offer balanced assortments to satisfy both the demand of target customers and the retailer's goals (Glock & Kunz, 1995; Kunz, 1996; Mason, Mayor, & Ezell, 1994; Robins, 1989).

A balanced assortment means that the varieties and quantities of styles, sizes, and colors included in inventory during a given period of time are closely matched to customer demand (Glock & Kunz, 1995; Troxell, 1976). Unbalanced assortments may lead to

1) stockouts and lost sales (Clodfelter, 1993);

2) unproductive use of space, promotional effort, and merchandise investment (Taylor, 1970);

3) high inventory carrying costs, low turnover, and poor store image (Dunne, Lusch, & Gable, 1995); as well as

4) loss of patronage (Lewison, 1994).

A balanced assortment is developed by merchandise budgeting and assortment planning (Glock & Kunz, 1995; Kunz, 1996; Troxell, 1976), historically referred to as dollar planning and unit planning respectively. Traditionally, merchandise budgeting preceded assortment planning; assortments were determined by overall dollar value instead of unit planning (Glock & Kunz, 1995; Rupe & Kunz, in review). Apparel firms focused on dollars related assortments instead of the assortments themselves to reduce the uncertainty of merchandise planning because creating merchandise assortments based on the assortments themselves required a lot of analysis of various social, demographic, aesthetic, economic, and environmental factors (Rupe & Kunz, in review). In the QR environment, dollars should follow customers' merchandise demand rather than dollars limiting the offerings of merchandise (Taylor, 1970; Glock & Kunz, 1995).

**Merchandise budgeting**

Merchandise budgeting is a financial management tool which determines the sales goals, dollar investment, and dollar open-to-buy by merchandise classifications, departments, or for an entire store for a particular period of time (Lewison, 1991; Kunz, 1996; Troxell, 1976). Dollar open-to-buy, the dollar value difference between planned purchases for a given period and all orders scheduled for delivery during that same period but not yet received, is a control device keeping stocks in line with actual sales (Troxell, 1976). The primary objectives of merchandise budgets include 1) offering appropriate levels of inventory at all times to satisfy customer demand, 2) arranging the time of purchases so that merchandise is available for sale neither too early nor too late, 3) keeping purchases within the store's ability to pay, and 4) keeping capital accessible at all times for the purchase of new goods when they may be needed (Troxell, 1976).

**Assortment planning**

Assortment planning is a merchandising management tool which determines the range of product choices, volume, and distribution according to assortment factors during a given time (Bohlinger, 1977; Glock & Kunz, 1995; Kunz & Rupe, in review; Lewison, 1991). For apparel, this range of product choices is usually determined by the number of styles, sizes, and colors (Glock & Kunz, 1995). The primary objectives of assortment planning include 1) offering the number and quantity of styles, sizes, and colors which can balance customer demand and sales goals during a given period, 2) arranging the time of delivering merchandise to the sales floor so that merchandise is available for sale neither too early nor too late, 3) keeping purchases at the level that the store is able to stock, display, promote, sell and pay for these purchases, and 4) keeping capital accessible at all times for purchases of new or additional goods when they may be needed (Troxell, 1976).

The methods of creating assortment plans include model stock, basic stock, or automated replenishment (Kunz, 1996). Model stock is used for seasonal and fashion goods (Kunz, 1996; Lewison, 1991). Basic stock is used for basic and staple goods (Bohlinger, 1977; Kunz, 1996). Detailed merchandise information such as brand name, price at cost and retail, style, size, and color is specified in basic stock (Bohlinger, 1977; Lewison, 1991). Automated replenishment is similar to basic stock. The major difference in automatic replenishment is that it uses information technology to automate manual activities (Buzzell & Ortmeyer, 1995).

The most commonly used terms for describing assortment dimensions are breadth and depth (Berman & Evans, 1995; Bohlinger, 1977; Clodfelter, 1993; Dunne, Lusch, & Gable, 1995; Lewison, 1991, 423; Mason, Mayor, & Ezell, 1994). However, there are no consistent definitions in these terms (Rupe & Kunz, in review). In addition, Rupe and Kunz (in review) indicated that the terms breadth and depth lacked quantitative meaning and did not identify the relationships between total number of units and total number of SKUs in each assortment. In order to help apparel firms effectively develop assortment plans, Rupe and Kunz (in review) proposed that the concept of volume per SKU for the assortment (VSA) be a means of reducing uncertainty related to assortment planning and helping merchandisers develop

assortment strategies. VSA is a measure that indicates the number of units allocated, on the average, for each SKU in a given assortment. Using the VSA, assortment diversity can be meaningfully described. Assortment diversity is "the range of relationships that can exist between assortment volume and number of SKUs in an assortment" (Rupe & Kunz, in review, p. 14). The smaller the VSA the more diverse the assortment, the large the VSA the more focused the assortment.

Rupe and Kunz (in review) used the Apparel Retail Model (ARM), a computer simulation program, to examine the relationship between the VSA and financial productivity. Based on single delivery, they found that the lower the VSA the poor the financial performance; the higher the VSA the better the financial performance. VSAs equal to 2, 5, 10, and 20 are key points with different financial outcomes. Assortment diversity at these points are described as more diverse, diverse, focused, and more focused. They also suggested several additional research topics that would further develop the concept of VSA including using ARM to test the performance of multiple delivery strategies in relation to VSA.

Multiple delivery strategies are one means of merchandise replenishment. Multiple delivery strategies employ an initial delivery and a series of reorders to accommodate customer needs and preferences and to adjust for merchandise planning errors ("Measuring the impact," 1991; Nuttle, King, & Hunter, 1991; Setren, 1993). In the traditional retail environment, there was little opportunity to adjust merchandise assortments offered during a selling period because of a lengthy lead time (King & Poindexter, 1991; Nuttle, King, & Hunter, 1991). Retailers ordered and received most apparel merchandise ahead of the selling period (Hunter, King, Nuttle, & Wilson, 1993; Taylor, 1970). Only one or two shipments were delivered during the selling period (Nuttle, King, & Hunter, 1991, 253). The remaining inventory not sent as part of the initial delivery was sent in predetermined weeks by merchandise plans. No demand re-estimation was employed during the selling period (Nuttle, King, & Hunter, 1991). QR multiple delivery strategies solve this problem by frequently re-estimating customer preferences based on the up-to-date POS data (Nuttle, King, & Hunter, 1991).

# MODEL DEVELOPMENT

The first objective of this study is to propose a model of merchandise replenishment process set in the context of the Behavioral Theory of the Apparel Firm. Literature related to merchandise replenishment and its relationship to merchandise planning is examined. The definition and concepts of merchandise replenishment process are described.

## Merchandise replenishment process

Replenishing merchandise by reordering best sellers during the selling period may increase the store's profit (Troxell, 1976) and reduce merchandisers' plan errors (King & Poindexter, 1991). Plan errors include assortment error and volume error. Volume error represents a difference between the actual demand volume and the planned volume. Assortment error represents differences in distribution of assortment factors between planned and actual demand. Both errors may be reduced by re-estimating customer demand after POS feedback. Merchandisers may revise the original plan and replenish merchandise that customers want (King & Poindexter, 1991).

In academic literature, there are limited descriptions of the process of merchandise replenishment. Hughes (1994) indicated that merchandise replenishment is the process of moving stock from suppliers to the retail sales floor. Setren (1993) indicated that the merchandise replenishment process involves purchase order creation, approval, vendor receiving, shipping, as well as retailer receiving and processing. Based on these descriptions and summarized from related literature, merchandise replenishment is defined here as the process of planning and placing reorders, as well as handling, shipping, receiving, distributing if necessary, and displaying merchandise. Based on this definition, a model of the merchandise replenishment process is proposed in Figure 4.

### Placing the initial order

The initial order may be based on basic stock, model stock, or automated stock plans (Kunz, 1996). The quantity of the initial order should be sufficient to take care of sales until a reorder can be placed and received (Taylor, 1970) if additional merchandise is desired. Retailers may place small initial orders for a variety of merchandise to observe customer

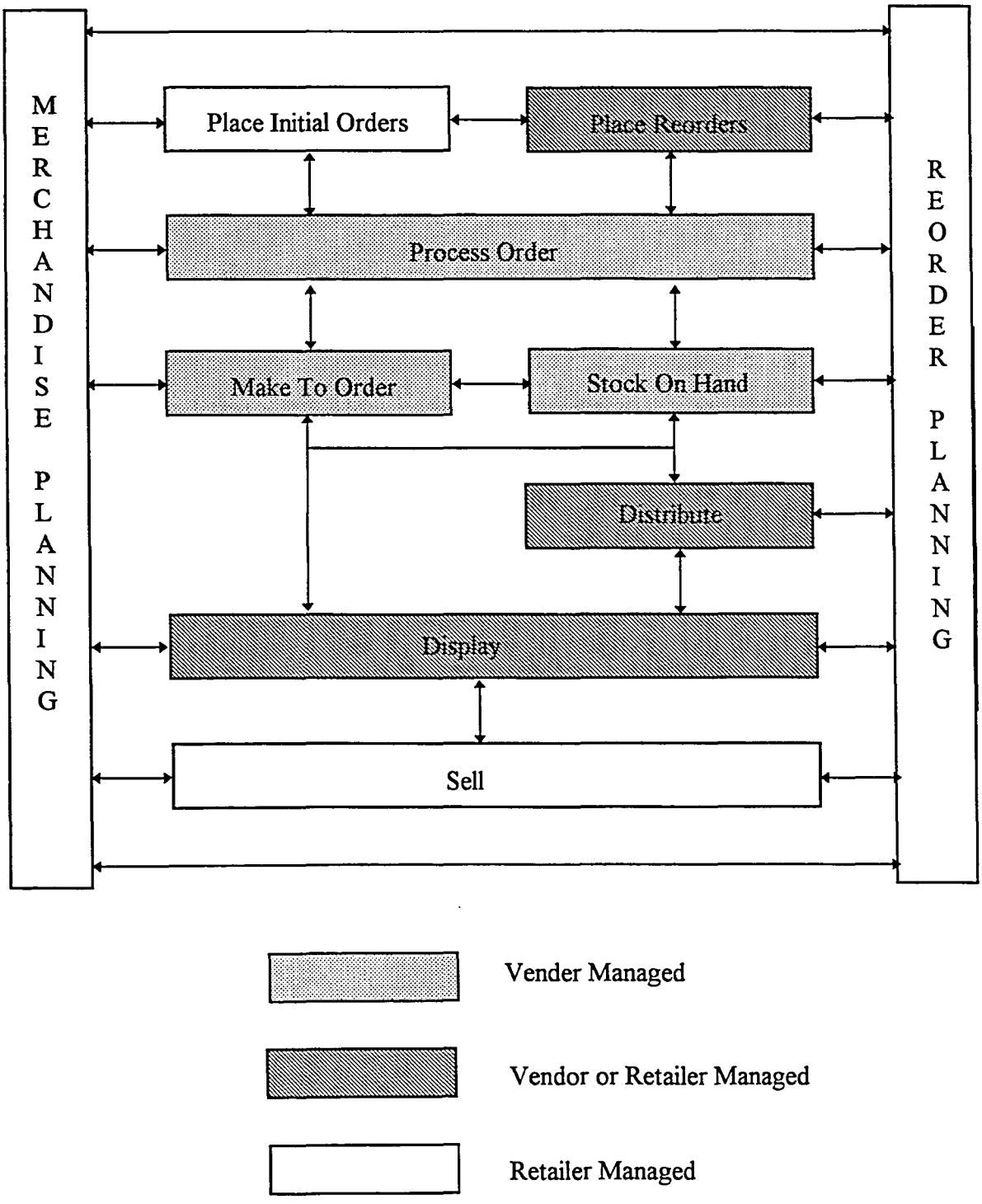



Figure 4. A model of merchandise replenishment process.

reactions. Preferred products are reordered in larger quantities than other products to reduce plan errors.

Initial delivery means that part or all of the initial order is shipped to the individual store at the beginning of the selling period. To be consistent with the VSA, this study uses volume per SKU for the initial delivery (VSID) to measure the quantity of initial delivery for each SKU. VSID is the number of units allocated on the average for each SKU in the initial delivery.

*VSID = units in the initial delivery / SKUs for the assortment*

Traditionally, initial delivery was determined by the percentage of total inventory (Nuttle, King, & Hunter, 1991; 1992). Merchandisers were not able to identify units of initial delivery allocated on the average for each SKU. VSID can be used to describe the relationship between total number of units in the initial delivery and total number of SKUs in an assortment. The smaller the VSID the fewer units allocated on the average in each SKU and the greater the possibility of stockouts and lost sales. Some examples as follows:

- An assortment with the initial delivery of 1000 units and total of 500 SKUs would have a VSID of 2.
- An assortment with the initial delivery of 1000 units and total of 200 SKUs would have a VSID of 5.
- An assortment with the initial delivery of 1000 units and total of 100 SKUs would have a VSID of 10.

Merchandisers may use the concept of VSID along with VSA to develop assortment and delivery strategies. They may compare the performance of assortments with the same VSA at different VSIDs or among different VSAs and VSIDs to make better decisions. After merchandisers identify the combinations of VSAs and VSIDs with the better assortment performance, they may manipulate the number of SKUs or volume for the assortment and initial delivery to get desired VSAs and VSIDs.

**Reorder planning**

Reorder planning is as important as original merchandise planning (Allen, 1982). It happens when an initial order is placed and part or all of the initial order is sold. Its objectives

involve correcting errors between merchandise plans and actual customer demand (Donnellan, 1996; Nuttle, King, & Hunter, 1991; Troxell, 1976) and keeping complete assortments during the selling period as well as minimizing residual inventory at the end of the selling period (Taylor, 1970). These objectives are accomplished by regularly monitoring inventory positions; carefully comparing actual sales against merchandise plans; identifying best-selling styles, colors, and sizes (Taylor, 1970); accurately re-estimating customer demand; and incorporating these re-estimations into reorders (Donnellan, 1996; Nuttle, King, & Hunter, 1991; Troxell, 1976).

The factors affecting reorder planning include:

1) the length of the selling period limits the number of reorders (Hunter, 1990). Merchandise with a short selling period may become more difficult to plan (Kunz, 1996).

2) the rate of sale is determined by analysis of past sales performance and predictions of new trends (Allen, 1982). Merchandise with considerably fluctuation in the rate of sale during a selling period needs more time and effort to plan (Troxell & Stone, 1981).

3) frequency of acquiring information affects the ease and accuracy in analyzing customer preferences and determining the quantities of reorders (Allen, 1982). Frequently updating information about purchase orders, sales records, merchandise transfers, returns from customers, returns to vendors, order cancellations, and price change from the stores may be helpful for re-estimating customer demand and adjusting original merchandise plans (Taylor, 1970; Troxell, 1976).

4) lead time for delivery of merchandise depends on the geographic location of the vendors, the overall demand of the specified item among competing retailers, and the vendor's perception of the importance of the retailer among vendor's customers (Bhat, 1985). Lengthy lead time forces retailers to reorder merchandise when a full inventory still exists (Berman & Evans, 1995).

5) the firm's expected customer service level determines the quantity of safety stock (Bohlinger, 1977). Maintaining safety stock may overcome stockouts and the uncertainty in demand and /or supply of merchandise (Lewison, 1991).

6) large purchases may get quantity discounts and reduce per-unit costs. Smaller orders may increase the cost per unit but reduce inventory carrying costs (Berman & Evans, 1995).

**Placing the reorder**

Reorders can be created by retailers or suppliers. Reorders generated by the suppliers may be prepared and shipped with or without retail merchandiser review and modifications (Buzzell & Ortmeyer, 1995; Gray, 1993). Traditionally, most reorders were created by retailers (Setren, 1993).

Reorders are preferably placed only after actual sales have given sufficient indication of the quantity customers are likely to buy (Taylor, 1970). Reorders are usually placed with current suppliers for previously purchased goods under terms and conditions specified by the initial order (Allen, 1982; Lewison, 1991). The methods of placing reorders include mailing, telephoning, electronically transmitting, and computer-to-computer transmitting (Lambert & Stock, 1993).

**Order processing**

Order processing includes entering the order, checking customer's credit, assembling, packing, invoicing, and arranging to ship (Buzzell & Ortmeyer, 1995; Lambert & Stock, 1993). The responsibilities for this process are taken by suppliers.

**Make to order/Stock on hand**

Purchase orders may be assembled from stock on hand or by production if not currently in inventory (Glock & Kunz, 1995; Lambert & Stock, 1993). Producing products after receiving the purchase orders is sometimes called make-to-order. From the manufacturers' perspectives, the goal of make-to-order is to have zero inventory at the beginning and end of the selling period (Glock & Kunz, 1995). Traditionally, basic and staple goods are assembled from stock on hand (Glock & Kunz, 1995; Taylor, 1970). Fashion and seasonal goods are often made-to-order (Glock & Kunz, 1995).

**Distributing**

Distributing is the process of receiving, sorting, storing, allocating, picking, and shipping merchandise. Receiving may happen in the individual store or distribution centers or

both. Receiving consists of checking and marking merchandise. The checking activities involve comparing the supplier's invoice and physical contents of shipments against the original purchase order, inspecting the incoming shipments for defects, and recording any disagreement (Buzzell & Ortmeyer, 1995; Lewison, 1994). Marking is the process of affixing or tagging the individual items with a price and other identifying information for stocking, controlling, and selling (Lewison, 1991).

The methods for receiving merchandise include direct store delivery, distribution center delivery, and cross-docking (Lewison, 1994). Direct store delivery means that merchandise is directly received in the individual stores. Since merchandise spends no time being stored in a distribution center this is the quickest way to move merchandise to individual stores (Gray, 1993). Distribution center delivery means that merchandise is first received in distribution centers and then shipped to individual stores after sorting and allocating. The time of merchandise storage in distribution centers depends on distribution plans and real sales data. Receiving merchandise at a distribution center permits retailers to adjust the allocation of merchandise based on sales during the time between preparation of an order and its receipt (Buzzell & Ortmeyer, 1995). Cross-docking means that "merchandise is received, sorted, and routed directly from receiving to shipping without spending any time in storage" (Lewison, 1994, p. G-4 ). The distribution center becomes a sorting area instead of a holding area (Lalonde, 1994).

**Displaying**

Displaying is the process of making merchandise available for the customer to buy. Displaying takes place in the individual store. Displaying involves moving merchandise to the sales floor for presentation or to the stock rooms for storage (Lewison, 1994). For reordered merchandise, merchandisers may use the same sales displays designed for original orders.

**Selling**

Selling is the process of changing ownership of merchandise from the retailer to the ultimate customer. POS records provide information for merchandisers to identify the characteristics of fast sellers, invest more money on up-trending categories, manage down-

trending categories to minimize markdowns (Setren, 1993), and make decisions on reorders and new product introductions (Kunz & Rupe, in review).

# METHODOLOGY FOR TESTING MULTIPLE DELIVERY STRATEGIES

The second objectives of this study was to evaluate the performance of multiple delivery strategies in relation to VSA for two selling periods by using Apparel Retail Model (ARM) simulation. The methods of manipulating ARM to evaluate the performance of multiple delivery strategies in relation to VSA were described. Data generated from ARM was adjusted to facilitate statistical analysis.

## Manipulation of Apparel Retail Model

ARM consists of the CHANGE program and the ARM program (Hunter, King, & Nuttle, 1991; Nuttle, King, & Hunter, 1991; Poindexter, 1991; Rupe & Kunz, in review). The simulation scenarios for both programs were defined as follows:

### Settings in the CHANGE program

Settings in the CHANGE program are shown in Table 1. Ten and 20 week selling periods were selected to represent fashion and seasonal goods with shorter and longer selling periods. The customer arrival rates for both selling periods were shown in Table 2. Both selling periods included 1000 customers and 1000 units to be sold.

The probabilities of in-store shopping behavior (Table 3) were Song's (1996). His research findings were used because the default settings were based on grocery stores. No research related to apparel in-store shopping behavior was available at the time ARM was developed (Poindexter, 1991).

Assortments with a VSA of 2, 5, 10, and 20 (Table 4) were selected because previous research indicated that the financial outcomes were different at these points (Rupe & Kunz, in review). The VSAs were calculated by holding the unit level constant at 1000 units and varying the level of SKUs at 500, 200, 100, and 50. Only one combination of SKU was selected for each VSA because Rupe and Kunz (in review) indicated that there were no differences among the possible combinations of SKUs within the same VSA. The percentage for each assortment factor was allocated evenly. For example, for an assortment with 5 styles,

Table 1. Settings in CHANGE program.

| Input categories | Scenarios |
|---|---|
| 1. The number of weeks for simulation | 10 and 20 |
| 2. The customer arrival rate curve | See Table 2 |
| 3. The number of customers expected during season | 1000 |
| 4. The planned number of units to sell during season | 1000 |
| 5. The probabilities that customers will take different paths in the branching diagram | See Table 3 |
| 6. Assortment plans | See Table 4 |
| 7. Customer demand profiles for styles, colors, sizes | Same as assortment plans |
| 8. The wholesale and retail prices | |
| • Wholesales price | $10 |
| • Retail price | $20 |
| • Jobbed off price | $10 |
| 9. The carrying and distribution expenses | |
| • Inventory carrying cost (annual %) | 20% |
| • Distribution cost (% of wholesale) | 8% |
| 10. The effect of markdown on customer response to stockouts | No markdowns |
| 11. The price elasticity of demand | 0.7 |

Table 2. Customer arrival pattern in two selling periods.

| 10 weeks selling period | | 20 weeks selling period | |
|---|---|---|---|
| Weeks | Weekly percentage | Weeks | Weekly percentage |
| 1-2 | 9.05 | 1-4 | 4.525 |
| 3-4 | 10.90 | 5-8 | 5.450 |
| 5-6 | 10.75 | 9-12 | 5.375 |
| 7-8 | 10.20 | 13-16 | 5.100 |
| 9-10 | 9.05 | 17-20 | 4.525 |

Table 3. Probabilities of in-store shopping behavior at Ramal (Song, 1996).

| | | |
|---|---|---|
| P1 | Percentage of customers who have an item in mind on arrival. | 89 |
| P2 | Percentage of customers who browse on arrival. | 11 |
| P3 | Percentage of customers who look for another item after a purchase. | 84 |
| P4 | Percentage of customers who leave after a purchase. | 0 |
| P5 | Percentage of customers who browse after a purchase. | 16 |
| P6 | Percentage of customers who alter their choice after a stockout. | 26 |
| P7 | Percentage of customers who leave after a stockout. | 34 |
| P8 | Percentage of customers who browse after a stockout | 40 |
| P9 | Percentage of customers who find a style when browsing | 0 |
| P10 | Percentage of customers who find a color when browsing | 0 |

Table 4. Assortment plans and customer demand profiles.

| VSA | Total units | SKU level | Combination of assortment factors (style x size x color) |
|---|---|---|---|
| 2 | 1000 | 500 | 5 x 10 x 10 |
| 5 | 1000 | 200 | 4 x 5 x 10 |
| 10 | 1000 | 100 | 4 x 5 x 5 |
| 20 | 1000 | 50 | 2 x 5 x 5 |

10 sizes, and 10 colors. Each style accounted for 20 percent. Each size and color was allocated for 10 percent respectively.

Customer demand profiles were the same as assortment plans because it was assumed that there were no plan errors as to the planned demand and actual demand.

**Settings in the ARM program**

Settings in the ARM program are shown in Table 5. The simulation mode of non-interactive with user-specified customer demand was selected because the purpose of this research was to provide guidelines for developing multiple delivery strategies before the selling period begins. For simplicity's sake, assortment plans were inputted from the CHANGE program. Assortment plans were changed from the CHANGE program only when a different VSA was examined. This method saved the time of inputting assortment plans for each simulation. Similarly, no editing of assortment plans, no plan errors between assortment plans and actual customer demand, no premium price, and no markdowns were taken for simulations. All merchandise was sold at the first price.

Delivery strategies involved four elements: 1) percentage of volume in an initial delivery, 2) frequency of additional deliveries, 3) percentage of volume in each additional delivery, and 4) timing of additional deliveries. Ten percentages of initial delivery, varied by reduction of 10 percent from 100 to 10, were used. The sizes of initial delivery at selected percentages for a given number of SKUs were calculated to get a VSID number (Table 6) because ARM rounds off the size of initial inventory into integers. Different percentages of initial delivery for a given number of SKUs might have same size of initial delivery. For

Table 5. Settings in the ARM program.

| Input categories | Scenarios |
|---|---|
| 1. The simulation mode | Non-interactive with user specified demand |
| 2. Initialize the assortment plan | Changed from the CHANGE program |
| 3. Edit the assortment plan | No editing |
| 4. Initialize plan errors | No plan errors |
| 5. Initialize premium | No premium |
| 6. Initialize markdowns | No markdowns |
| 7. Initial delivery strategies | See Table 7 and 8 |

Table 6. VSID used for different sizes of initial delivery and number of SKUs .

| | SKUs | | | |
|---|---|---|---|---|
| Initial delivery (units) | 500 | 200 | 100 | 50 |
| 100 | 1 | 1 | 1 | 2 |
| 200 | 1 | 1 | 2 | 4 |
| 300 | 1 | 2 | 3 | 6 |
| 400 | 1 | 2 | 4 | 8 |
| 500 | 1 | 3 | 5 | 10 |
| 600 | 1 | 3 | 6 | 12 |
| 700 | 1 | 4 | 7 | 14 |
| 800 | 2 | 4 | 8 | 16 |
| 900 | 2 | 5 | 9 | 18 |
| 1000 | 2 | 5 | 10 | 20 |

example, for an assortment with 500 SKUs and 1000 units of planned inventory, both 80 percent and 90 percent of initial delivery generated 1000 units of initial delivery.

At each percentage of initial delivery, 1 to 6 and 1 to 13 additional deliveries were examined for the 10 and 20 week selling period respectively. The percentage of volume in each additional delivery was evenly allocated depending on the percentage of volume left for additional deliveries.

The timing of additional deliveries for both selling periods is shown in Tables 7 and 8. The week numbers represented merchandise received at the end of the specified week. Four principles related to real world strategies were used to determine the timing of additional deliveries: 1) The lead time was 1 week because 1 week was the shortest lead time allowed by ARM. 2) The first additional delivery was shipped at week 2 or later because merchandise reordering must be based on information from, at a minimum, the first week sales. 3) In order to achieve the goal of zero to zero inventory, the final delivery was shipped at the 7th week for the 10 week selling period and the 14th week for the 20 week selling period (about two thirds through the selling period). After the final delivery, merchandisers might use various strategies to reduce residual inventory such as markdowns and jobbing residual inventory off at the end of the selling period. For this study, residual inventory at the end of the selling period was sold at cost of merchandise. 4) The intervals between additional deliveries were evenly allocated for the selling period. If the intervals between additional deliveries were not uniform , the first few additional deliveries had shorter intervals.

Based on these settings, the quantities of strategy combinations conducted in the ARM program were determined. For the 10 week selling period, 220 strategy combinations (4 levels of VSAs at 9 percentages of initial delivery across 6 additional deliveries and one single delivery for each level of VSAs) were performed. For the 20 week selling period, 472 strategy combinations (4 levels of VSAs at 9 percentages of initial delivery across 13 additional deliveries and one single delivery for each level of VSAs) were performed. Because of the random characteristics of ARM simulations and recommendations of previous research

Table 7. Timing of additional deliveries for the 10 week selling period.

| Frequency of additional deliveries | Weeks in the selling period | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | | | X | | | |
| 2 | | X | | | | X |
| 3 | X | | X | | | X |
| 4 | X | X | | X | | X |
| 5 | X | X | X | X | | X |
| 6 | X | X | X | X | X | X |

Table 8. Timing of additional deliveries for the 20 week selling period.

| Frequency of additional deliveries | weeks in the selling period | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | | | | | | X | | | | | | | |
| 2 | | | | | | X | | | | | | | X |
| 3 | | | X | | | | | X | | | | | X |
| 4 | | X | | | X | | | | X | | | | X |
| 5 | X | | | X | | | X | | | X | | | X |
| 6 | X | | X | | X | | X | | | X | | | X |
| 7 | X | | X | | X | | X | | X | | X | | X |
| 8 | X | X | X | | X | | X | | X | | X | | X |
| 9 | X | X | X | X | X | | X | | X | | X | | X |
| 10 | X | X | X | X | X | X | X | | X | | X | | X |
| 11 | X | X | X | X | X | X | X | X | X | | X | | X |
| 12 | X | X | X | X | X | X | X | X | X | X | X | | X |
| 13 | X | X | X | X | X | X | X | X | X | X | X | X | X |

(Hunter, King, & Nuttle, 1991; Rupe and Kunz, in review), each strategy combination was replicated five times to increase the reliability of data.

**Performance measures**

Nine performance measures were selected for preliminary analysis of these strategy combinations: percent adjusted gross margin, percent gross margin, percent jobbed off, percent lost sales, percent total stockouts, average inventory, gross margin, gross margin return on inventory (GMROI), and total revenue. These measures were selected based on previous research using ARM as a research method (Hunter, King, & Nuttle, 1991; Nuttle, King, & Hunter, 1991; Rupe & Kunz, in review). Table 9 shows definitions of these measures.

Table 9. Definitions of performance measures.

1. Average inventory: the average number of units in stock within a specified selling period.
2. Gross margin return on inventory: gross margin dollars divided by the average dollar investment in inventory.
3. Gross margin: total revenue minus total cost of goods.
4. Percent adjusted gross margin: gross margin minus distribution and inventory carrying costs divided by total revenue.
5. Percent gross margin: total revenue minus total cost of goods divided by total revenue.
6. Percent jobbed off: residual inventory at the end of the selling period divided by total inventory.
7. Percent lost sales: the amount of total lost sales divided by total inventory.
8. Percent total stockouts: the amount of total stockouts divided by total inventory.
9. Total revenue: sales revenue plus job off revenue.

## Data adjustments

Data produced by the ARM simulation were adjusted before statistical analysis. Data adjustments included giving a negative symbol for some measures and excluding anomalous data to facilitate data analysis. Whether a high or low number is a favorable ratios depends on the nature of the performance measure. Therefore, four measures including percent jobbed off, percent lost sales, percent total stockouts, and average inventory were given a negative sign to help computers and readers understand performance in the same way. With the adjustment, the higher the number of the performance measure the better the performance. For example, if average inventory of -200 and -400 were compared, average inventory of -200 was better.

Anomalous data had two characteristics including the same total inventory and the same quantity of units in each additional delivery among the 5 replications of strategy combinations. For example, for the 20 week selling period with a VSA of 2, using 30 percent initial delivery and 7 additional deliveries, the simulation generated 500 units in each additional delivery and 4000 units of total inventory even though the planned total units in the selling period was only 1000 units. The cause of this anomalous data could not be identified from the ARM manual or related literature. For this study, it was treated as a limitation of the ARM simulation. After excluding 2 and 37 strategy combinations for the 10 and 20 week selling periods respectively, the remaining 218 and 435 strategy combinations were kept for subsequent data analysis.

# DATA ANALYSIS AND RESULTS

The process of data analysis included two stages. In the first stage, principle component factor analysis was used to identify prominent dimensions of performance measures when multiple delivery strategies were used. In the second stage, performance dimensions derived from the first stage were used to test hypotheses. Table 10 shows a summary of the hypotheses and their statistical test methods. The statistical methods and results were discussed along with each hypothesis.

Table 10. Hypotheses and test methods.

| Hypotheses | Test methods |
|---|---|
| H 1. With the same selling period, the VSA, VSID, and FAD are not interdependent in their influence on performance of assortments. | ANOVA |
| H 2. FAD does not significantly affect performance of assortments with the same selling period, VSA, and VSID. | ANOVA<br>LSD |
| H 3: With the same selling period and VSA, there are no significant differences in performance of assortments between using single delivery strategy and multiple delivery strategies. | T-test |

**Performance measure dimensions**

Principle component factor analysis with varimax rotation was conducted on nine performance measures to identify the commonality among the measures. Eigenvalues of greater than 1 (Manly, 1986) were used to determine the number of factors. These factors were rotated orthogonally (varimax) to assist in the interpretation. With the exception of one measure loading at 0.53, measure loadings greater than or equal to 0.70 were considered representatives of their respective factors and were used in interpreting the meaning of the factors. No measure was included in more than one factor.

Two independent factors were generated from the principle component factor analysis for both selling periods. They explained 93.45 and 87.90 percent of the variance for the 10

and 20 week selling period respectively (Table 11). The first factor explained 46.23 and 47.55 percent of the variance for the 10 and 20 week selling period respectively. Four measures including percent total stockouts, percent lost sales, gross margin, and total revenue had large positive loadings on this factor. The factor loadings ranged from 0.88 to 0.97 for the 10 week selling period and from 0.85 to 0.94 for the 20 week selling period. This factor was labeled revenue and service (RS).

Table 11. Factors and item loadings after rotation (VARIMAX) for nine performance measures for two selling periods.

| Factor title and items | Item loadings | |
|---|---|---|
| | 10 week selling period | 20 week selling period |
| 1. Revenue and service (RS) | | |
| • Percent total stockouts | 0.94660 | 0.93669 |
| • Percent lost sales | 0.94527 | 0.93759 |
| • Gross margin | 0.97299 | 0.96140 |
| • Total revenue | 0.87791 | 0.84677 |
| Percent variance | 46.23 % | 47.55 % |
| 2. Inventory and profitability (IP) | | |
| • Percent jobbed off | 0.98833 | 0.98219 |
| • Percent gross margin | 0.98948 | 0.98092 |
| • Percent adjusted gross margin | 0.98951 | 0.53407 |
| • GMROI | 0.71079 | 0.74211 |
| • Average inventory | 0.76021 | 0.79278 |
| Percent variance | 47.22 % | 40.35 % |

The second factor accounted for 47.22 and 40.35 percent of the variance for the 10 and 20 week selling period respectively. It was composed of five measures: percent jobbed off, percent gross margin, percent adjusted gross margin, gross margin return on inventory (GMROI), and average inventory. The factor loadings ranged from 0.71 to 0.99 for the 10 week selling periods and from 0.53 to 0.98 for the 20 week selling period. This factor was called inventory and profitability (IP).

The results indicated that when multiple delivery strategies were used, the measures in the RS and IP factors were homogeneous respectively. The major reasons were that all merchandise was sold at first price and the residual inventory at the end of the selling period was sold at cost. Thus, the measures in the RS factor were only affected by the quantity of merchandise sold and the measures in the IP factor were only affected by the quantity of merchandise sold and on hand. In terms of the RS factor, reducing percent total stockouts led to decreased percent lost sales and increased gross margin and total revenue because more customers got merchandise they wanted. In terms of the IP factor, reducing average inventory resulted in decreased percent jobbed off as well as increased percent gross margin, percent adjusted gross margin, and GMROI because less merchandise was stocked on the average and the same or more merchandise was sold during the selling period.

RS and IP were used in place of the original 9 performance measures and became the new measures used to evaluate the performance of multiple delivery strategies at four levels of VSA for two selling periods. The scores of RS and IP were formed by summing the standardized original data of selected measures based on factor loadings. The scores of RS and IP in selected strategy combinations were derived by using the SCORE procedure in the SAS program.

In order to understand the influence of considering both factors at the same time for different strategy combinations, a third performance measure was created and named overall performance (OP). The scores of OP for selected strategy combinations were determined by summing the scores of RS and IP since both factors had a similar percentage of variances. The scores of these three new measures were used for subsequent analysis and discussion.

## Tests of hypotheses

**H 1. With the same selling period, the VSA, VSID, and FAD are not interdependent in their influence on performance of assortments**

The first hypothesis examined whether performance of assortments would vary given different volume per SKU for the assortment (VSA), volume per SKU for the initial delivery (VSID), and frequency of additional deliveries (FAD). Analysis of variance (ANOVA) procedures in which the VSA, VSID, and FAD were the independent variables and RS, IP, and OP served as dependent variables respectively were used to test Hypothesis 1. Significant F ratios ($p < 0.0001$) were obtained for all three performance measures for both selling periods (Table 12). The first null hypothesis was rejected. Performance of assortments depended on combinations of the VSA, VSID, FAD. Different VSAs, VSIDs, or FAD generated different assortment performance.

Table 12. F values for analysis of variance in assortment performance for two selling periods using the VSA, VSID, and FAD as independent variables.

| | 10 week selling period | | | 20 week selling period | | |
|---|---|---|---|---|---|---|
| Effects | RS [a] | IP [b] | OP [c] | RS | IP | OP |
| VSA | 511.08 * | 10584.49 * | 5276.89 * | 1537.62 * | 19289.56 * | 9131.78 * |
| VSID | 2847.56 * | 339.78 * | 434.87 * | 3970.10 * | 1878.70 * | 429.62 * |
| FAD [d] | 706.27 * | 210.54 * | 441.90 * | 715.37 * | 150.45 * | 303.07 * |
| VSA x VSID | 283.47 * | 19.19 * | 57.22 * | 393.86 * | 87.30 * | 74.15 * |
| VSA x FAD | 25.24 * | 6.96 * | 8.84 * | 45.63 * | 8.46 * | 23.92 * |
| VSID x FAD | 59.23 * | 7.96 * | 24.17 * | 100.86 * | 3.82 * | 46.72 * |
| VSA x VSID x FAD | 15.46 * | 2.13 * | 4.78 * | 22.97 * | 1.77 * | 11.56 * |

* $p <= 0.0001$.

[a] RS: revenue and service; [b] IP: inventory and profitability; [c] OP: overall performance; [d] FAD: frequency of additional deliveries.

**H 2. FAD does not significantly affect performance of assortments with the same selling period, VSA, and VSID.**

The second hypothesis examined whether the FAD affects performance of assortments when the selling period, VSA, and VSID were constant. ANOVA procedures in which the FAD were independent variables and RS, IP, and OP served as dependent variables respectively were used to test Hypothesis 2. Significant F ratios ($p$'s $< 0.05$) were obtained at most levels of VSA and VSID for both selling periods. Hypothesis 2 was mostly rejected. The FAD did significantly affect performance of assortments at most levels of VSID and VSA for both selling periods. Different numbers of additional deliveries generated significantly different performance of assortments. The results of the test of Hypothesis 2 are shown in Table 13.

Least significant difference (LSD) multiple comparisons were performed at levels of VSA and VSID where performance of assortments were significantly affected by FAD. The purpose was to further identify the FAD with the best performance of assortments at selected levels of VSA and VSID for both selling periods. The significant level was set at 0.05 for all comparisons.

The results of LSD multiple comparisons for different strategy combinations are shown in Appendix A because of the numerous LSD tests performed in this study. Table 14 was used to illustrate the results of LSD tests. This example is the result of LSD tests for the 20 week selling period with a VSA of 2 and a VSID of 1.

In Table 14, FAD is ranked by its mean RS scores in descending order. Six additional deliveries with the mean score of -0.201960 perform best across 13 additional deliveries. The column of LSD's grouping shows the results of LSD test for the RS scores at different numbers of additional deliveries. The RS scores across 13 additional deliveries with the same letter are not significantly different from one another at 0.05 level. If the letter of one group has some overlap with the letters of other groups, it means that there are no significant differences in RS scores among these groups. Some overlap exists in group A, B, C, and D and FAD in these groups range from 3 to 12. Three to 12 additional deliveries get the

Table 13. F values for analysis of variance in performance of assortments for two selling periods using FAD at selected levels of VSA and VSID as independent variables.

| | | The 10 week selling period | | | The 20 week selling period | | |
|---|---|---|---|---|---|---|---|
| VSA | VSID | RS [a] | IP [b] | OP [c] | RS | IP | OP |
| 2 | 1 | 24.40 *** | 17.06 *** | 17.39 *** | 17.05 *** | 15.31 *** | 10.31 *** |
| | 2 | 2.50 | 5.81 ** | 3.34 * | 1.77 | 4.24 *** | 2.20 * |
| 5 | 1 | 52.24 *** | 4.18 ** | 20.56 *** | 84.25 *** | 3.19 ** | 34.51 *** |
| | 2 | 27.62 *** | 5.11 ** | 13.96 *** | 21.93 *** | 4.45 *** | 9.14 *** |
| | 3 | 16.28 *** | 7.38 *** | 12.43 *** | 10.73 *** | 7.86 *** | 8.17 *** |
| | 4 | 3.60 * | 2.70 * | 2.00 | 3.10 ** | 6.82 *** | 2.59 ** |
| | 5 | 1.24 | 1.81 | 0.78 | 0.51 | 3.74 *** | 1.17 |
| 10 | 1 | 228.30 *** | 13.63 *** | 155.42 *** | 384.04 *** | 15.77 *** | 26.38 *** |
| | 2 | 195.67 *** | 7.49 *** | 60.49 *** | 118.60 *** | 1.74 | 46.81 *** |
| | 3 | 49.75 *** | 12.90 *** | 34.00 *** | 50.61 *** | 4.89 *** | 24.02 *** |
| | 4 | 22.31 *** | 24.99 *** | 35.22 *** | 21.91 *** | 2.53 * | 5.16 *** |
| | 5 | 20.91 *** | 14.45 *** | 23.99 *** | 8.03 *** | 9.36 *** | 6.89 *** |
| | 6 | 10.77 *** | 10.22 *** | 12.37 *** | 8.76 *** | 7.22 *** | 7.30 *** |
| | 7 | 9.06 *** | 4.76 ** | 8.03 *** | 5.43 *** | 8.85 *** | 5.77 *** |
| | 8 | 3.74 * | 1.39 | 2.22 | 2.65 ** | 5.61 *** | 3.50 *** |
| | 9 | 2.53 | 1.44 | 1.73 | 1.40 | 3.25 ** | 1.54 |
| 20 | 2 | 300.77 *** | 12.14 *** | 155.13 *** | 374.83 *** | 24.76 *** | 278.34 *** |
| | 4 | 166.45 *** | 15.14 *** | 89.59 *** | 122.35 *** | 0.88 | 50.55 *** |
| | 6 | 22.06 *** | 15.97 *** | 24.06 *** | 31.05 *** | 4.82 *** | 17.69 *** |
| | 8 | 18.80 *** | 19.03 ** | 29.46 *** | 10.67 *** | 3.02 ** | 6.91 *** |
| | 10 | 8.54 *** | 7.38 *** | 11.59 *** | 7.87 *** | 6.27 *** | 7.45 *** |
| | 12 | 6.64 *** | 8.74 *** | 10.61 *** | 3.80 *** | 9.57 *** | 6.71 *** |
| | 14 | 2.30 | 2.60 | 2.85 * | 2.68 ** | 6.16 *** | 3.82 *** |
| | 16 | 3.73 * | 1.45 | 2.78 * | 1.97 | 3.07 ** | 2.13 * |
| | 18 | 1.70 | 1.30 | 1.34 | 1.12 | 2.62 ** | 1.39 |

* $p <= 0.05$; ** $p <= 0.01$; *** $p <= 0.001$.

[a] RS: revenue and service; [b] IP: inventory and profitability; [c] OP: overall performance.

Table 14. One example of the results of LSD tests selected from the 20 week selling period with a VSA of 2 and a VSID of 1.

| Frequency of additional deliveries (FAD) | Revenue and Service (RS) [a] | LSD's grouping [b] |
|---|---|---|
| 6 | -0.20196 | A |
| 10 | -0.31500 | A, B |
| 5 | -0.32095 | A, B |
| 9 | -0.32166 | A, B |
| 3 | -0.37823 | A, B |
| 4 | -0.38566 | B, C |
| 8 | -0.51318 | D, C |
| 7 | -0.54708 | D, C |
| 11 | -0.57417 | D |
| 12 | -0.58337 | D |
| 13 | -0.88059 | E |
| 1 | -0.95521 | E |
| 2 | -1.03065 | E |

[a] A higher mean score indicates better performance; [b] Least significant difference. Scores with the same letter were not significantly different from one other at the 0.05 level.

significantly best performance of assortments in RS scores while there are no significant differences in RS among 3 to 12 additional deliveries. These results are summarized into Table 15. The results of LSD tests for all other strategy combinations are also summarized into Table 15 based on the same process of summarization.

In Table 15, the first two columns show levels of VSA and VSID. The next six columns show numbers of additional deliveries with the best performance of assortments on

Table 15. Summary of results of LSD tests for FAD at selected levels of VSAs and VSIDs with the significantly best performance of assortments for two selling periods.

| | | Frequencies of additional deliveries (FAD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | The 10 week selling period | | | The 20 week selling period | | |
| VSA | VSID | RS [a] | IP [b] | OP [c] | RS | IP | OP |
| 2 | 1 | 4-6 | 2, 5, 6 | 5-6 | 3-12 | 2 | 2-13 |
| | 2 | | 6 | 1-6 | | 1-13 | 1-13 |
| 5 | 1 | 3-6 | 1-6 | 4-6 | 3-13 | 1-13 | 3-13 |
| | 2 | 3-6 | 1-6 | 2-6 | 3-13 | 1-13 | 2-13 |
| | 3 | 3-6 | 6 | 2-6 | 3-13 | 2-13 | 2-13 |
| | 4 | 2-6 | 1-6 | | 2-13 | 1-13 | 2-13 |
| | 5 | | | | | 2 | |
| 10 | 1 | 4 | 6 | 3-6 | 4-13 | 3-13 | 4-13 |
| | 2 | 3-6 | 6 | 3-6 | 4-13 | | 3-13 |
| | 3 | 5 | 6 | 4-6 | 4-13 | 2-13 | 3-13 |
| | 4 | 3-6 | 6 | 4-6 | 4-13 | 2-13 | 4-13 |
| | 5 | 3-6 | 2-6 | 2-6 | 3-13 | 2-13 | 2-13 |
| | 6 | 3-6 | 2-6 | 2-6 | 3-13 | 2-13 | 2- 13 |
| | 7 | 2-6 | 2-6 | 2-6 | 2-13 | 1-13 | 2-13 |
| | 8 | 2-6 | | | 2-13 | 1-13 | 2-13 |
| | 9 | | | | | 1-13 | |
| 20 | 2 | 3-6 | 2-6 | 3-6 | 4-13 | 3-13 | 6-13 |
| | 4 | 5 | 6 | 5-6 | 4-13 | | 3-13 |
| | 6 | 3-6 | 2-6 | 3-6 | 4-13 | 2-13 | 3-13 |
| | 8 | 3-6 | 2-6 | 2-6 | 3-13 | 1-13 | 3-13 |
| | 10 | 3-6 | 6 | 2-6 | 3-13 | 2-13 | 2-13 |
| | 12 | 2-6 | 2-6 | 2-6 | 2-13 | 2-13 | 2-13 |
| | 14 | | | 1-6 | 2-13 | 2-13 | 2-13 |
| | 16 | 2-6 | | 2-6 | | 1-12 | 2-12 |
| | 18 | | | | | 1-13 | |

* $p <= 0.05$.

[a] RS: revenue and service; [b] IP: inventory and profitability; [c] OP: overall performance.

three performance measures for two selling periods. For example, for the 10 week selling period in terms of RS under with a VSA of 2 and VSID of 1, 4 to 6 additional deliveries can get the best performance. If the cell in Table 15 is blank, it means that FAD did not affect performance of assortments. The result may provide guidelines for merchandisers determining frequency of additional deliveries.

Although Hypothesis 2 identifies FAD with the best performance of assortments at given levels of VSA and VSID, whether the result of multiple deliveries is better than the result of single delivery is unclear. In order to provide effective guidelines for developing delivery strategies, Hypothesis 3 was proposed to compare multiple delivery strategies with the best performance of assortments to the performance of assortments by using single delivery strategy.

**H 3: With the same selling period and VSA, there are no significant differences in performance of assortments between using single delivery strategy and multiple delivery strategies.**

This hypothesis examined whether multiple delivery strategies did improve performance of assortments compared to single delivery strategy given the same selling period and VSA. Based on the results of Hypothesis 2, only the lowest numbers of additional deliveries at selected VSIDs with the significantly best performance of assortments were selected as representatives of multiple delivery strategies. It was assumed that merchandisers preferred to select the lowest numbers of additional deliveries to reduce the time and cost of reordering and handling inventory.

T tests were used to test Hypothesis 3. The performance of assortments for four selected VSAs for both selling periods by using multiple delivery strategies and single delivery strategy is presented in Appendix A and B respectively. The results of T tests are presented in Table 16. The acceptable significance was $p = 0.05$.

Assortment performance for both selling periods was able to be improved by using multiple delivery strategies except the OP measure for the 10 week selling period. In terms of RS measure, strategy combinations with the better performance than single delivery were described by the length of selling periods. For the 10 week selling period, the strategy

Table 16. The results of T tests in performance of assortments for two selling periods by using multiple delivery strategies and single delivery strategy.

| | | Frequency of additional deliveries (FAD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | The 10 week selling period | | | The 20 week selling period | | |
| VSA | VSID | RS [a] | IP [b] | OP [c] | RS | IP | OP |
| 2 | 1 | 4 * | 2 | 5 | 3 * | 2 | 1 |
| | 2 | | 6 | 1 | | 1 | 1 |
| 5 | 1 | 3 | 1 | 4 | 3 | 1 * | 3 |
| | 2 | 3 | 1 | 2 | 3 | 1 | 2 |
| | 3 | 3 * | 6 | 2 | 3 * | 2 | 2 |
| | 4 | 2 * | 1 | | 2 * | 1 | 2 * |
| | 5 | | | | | 2 | |
| 10 | 1 | 4 | 6 * | 3 | 4 | 3 * | 4 |
| | 2 | 3 | 6 * | 3 | 4 | | 3 |
| | 3 | 5 | 6 * | 4 | 4 | 2 * | 3 |
| | 4 | 3 | 6 * | 4 | 4 | 2 * | 4 |
| | 5 | 3 | 2 | 2 | 3 | 2 * | 2 |
| | 6 | 3 * | 2 | 2 | 3 * | 2 * | 2 |
| | 7 | 2 * | 2 | 2 | 2 * | 1 | 2 * |
| | 8 | 2 * | | | 2 * | 1 | 2 * |
| | 9 | | | | | 1 | |
| 20 | 2 | 3 | 2 * | 3 | 4 | 3 * | 6 |
| | 4 | 5 | 6 * | 5 | 4 | | 3 |
| | 6 | 3 | 2 | 3 | 4 | 2 * | 3 |
| | 8 | 3 | 2 | 2 | 3 | 2 * | 3 * |
| | 10 | 3 | 6 | 2 | 3 | 2 * | 2 |
| | 12 | 2 | 2 | 2 | 2 | 2 * | 2 * |
| | 14 | | | 1 | 2 * | 2 | 2 * |
| | 16 | 2 * | | 2 | | 1 | 2 * |
| | 18 | | | | | 1 | |

* $p < 0.05$.

[a] RS: revenue and service; [b] IP: inventory and profitability; [c] OP: overall performance.

combinations included 1) an assortment with a VSA of 2, a VSID of 1, and 4 additional deliveries; 2) an assortment with a VSA of 5, a VSID of 3, and 3 additional deliveries or with a VSID of 4 and 2 additional deliveries; 3) an assortment with a VSA of 10, a VSID of 6, and 3 additional deliveries, with a VSID of 7 and 2 additional deliveries, or with a VSID of 8 and 2 additional deliveries; 4) an assortment with a VSA of 20, a VSID of 16, and 2 additional deliveries. For the 20 week selling period, the strategy combinations included 1) an assortment with a VSA of 2, a VSID of 1, and 3 additional deliveries; 2) an assortment with a VSA of 5, a VSID of 3, and 3 additional deliveries or with a VSID of 4 and 2 additional deliveries; 3) an assortment with a VSA of 10, a VSID of 6, and 3 additional deliveries, with a VSID of 7 and 2 additional deliveries, or with a VSID of 8 and 2 additional deliveries; 4) an assortment with a VSA of 20, a VSID of 14, and 2 additional deliveries.

Multiple delivery strategies are not always better than single delivery. The limitations of using multiple delivery strategies were identified for both selling periods. First, when VSIDs was close to VSAs, performance of assortments in RS by using multiple delivery strategies was similar to that of using single delivery strategies. Larger initial delivery reduced the possibility of using additional deliveries to correct plan errors and accommodate customer demand during the selling period because little inventory was available for replenishment. Second, smaller initial delivery (smaller VSIDs) led to inadequate inventory available on the sales floor. Customers might encounter stockouts before the merchandise was replenished.

In terms of IP measures, strategy combinations with the better performance than single delivery were described as follows: for the 10 week selling period, the strategy combinations included 1) assortment with a VSA of 10, a VSID of 4 or less, and 6 additional deliveries; 2) an assortment with a VSA of 20, a VSID of 2, and 2 additional deliveries or with a VSID of 4 and 6 additional deliveries. For the 20 week selling period, the strategy combinations included 1) an assortment with a VSA of 5, a VSID of 1, and 1 additional delivery; 2) an assortment with a VSA of 10, a VSID of 1, and 3 additional deliveries or with a VSID of 3 to 6 and 2 additional deliveries; 3) an assortment with a VSA of 20, a VSID of 2, and 3 additional deliveries or with a VSID of 6 to 12 and 2 additional deliveries.

Reduced average inventory was the major reason for the improved performance in IP. Reduced average inventory was achieved by fewer units allocated in the initial delivery (the smaller number of VSID) or frequent replenishment of merchandise. The results indicated that the proportion of total units allocated in the initial delivery was the major reason for reduced average inventory. If the proportion of total units allocated in the initial delivery were small enough, even 1 additional delivery could improve the level of inventory and profitability. However, this strategy may also result in higher stockouts because inadequate inventory was stocked on the sales floor at the beginning of the selling period.

In terms of OP measures, multiple delivery strategies were able to get better performance than single delivery only for the 20 week selling period. The strategy combinations included 1) an assortment with a VSA of 5, a VSID of 4, and 2 additional deliveries; 2) an assortment with a VSA of 10, a VSID of 7 or 8, and 2 additional deliveries; 3) an assortment with a VSA of 20, a VSID of 8, and 3 additional deliveries or with a VSID of 12 to 16 and 2 additional deliveries.

The results indicated that when RS and IP factors were considered together, multiple delivery strategies were useful only for the longer selling period. For a selling period of 10 weeks or less, multiple delivery strategies may be useless. One of the reasons might be the shortest lead time assumed in this study is one week. Future research may evaluate whether multiple delivery strategies were able to improve the performance of assortments if the lead time was reduced.

Table 17 simplified from Table 16 provides guidelines for developing delivery strategies considering the VSA and the length of the selling periods. For example, for the 10 week selling period in the RS measure, an assortment with a VSA of 2, a VSID of 1, and 4 additional deliveries got better performance compared to performance of assortments using single delivery. If the cell is blank, it means that single delivery is suggested for selected VSA and length of selling period.

Table 17. Strategy combinations with better performance compared to performance of assortments using single delivery.

| | | Frequency of additional deliveries (FAD) | | | | | |
|---|---|---|---|---|---|---|---|
| | | The 10 week selling period | | | The 20 week selling period | | |
| VSA | VSID | RS [a] | IP [b] | OP [c] | RS | IP | OP |
| 2 | 1 | 4 | | | 3 | | |
| | 2 | | | | | | |
| 5 | 1 | | | | | 1 | |
| | 2 | | | | | | |
| | 3 | 3 | | | 3 | | |
| | 4 | 2 | | | 2 | | 2 |
| | 5 | | | | | | |
| 10 | 1 | | 6 | | | 3 | |
| | 2 | | 6 | | | | |
| | 3 | | 6 | | | 2 | |
| | 4 | | 6 | | | 2 | |
| | 5 | | | | | 2 | |
| | 6 | 3 | | | 3 | 2 | |
| | 7 | 2 | | | 2 | | 2 |
| | 8 | 2 | | | 2 | | 2 |
| | 9 | | | | | | |
| 20 | 2 | | 2 | | | 3 | |
| | 4 | | 6 | | | | |
| | 6 | | | | | 2 | |
| | 8 | | | | | 2 | 3 |
| | 10 | | | | | 2 | |
| | 12 | | | | | 2 | 2 |
| | 14 | | | | 2 | | 2 |
| | 16 | 2 | | | | | 2 |
| | 18 | | | | | | |

[a] RS: revenue and service; [b] IP: inventory and profitability; [c] OP: overall performance.

# SUMMARY

Quick response (QR) business systems provide a competitive advantage for apparel firms to survive in the domestic and foreign markets. Kunz (1996) described QR as being composed of three concepts: time-based competition, agility, and partnerships. The literature review related to QR elaborated on these concepts. The relationship of QR to Behavioral Theory of the Apparel Firm was also addressed.

Merchandise planning is one of the major challenges for effectively and efficiently executing QR business systems (Hammond, 1993). Merchandise planning includes merchandise budgeting and assortment planning. Few guidelines are available to help merchandisers determine successful merchandise assortments (Rupe & Kunz, in review). Apparel retail model (ARM), an interactive computer simulation, provides one way of estimating the performance of assortment planning (Hunter, King, & Nuttle, 1991; Nuttle, King, & Hunter, 1991; 1992). Using ARM as a research tool and the Behavioral Theory of the Apparel Firm (Kunz, 1995) as a research framework, Rupe and Kunz (in review) proposed the concept of volume per SKU in an assortment (VSA) as a tool of reducing uncertainty related to assortment planning and helping merchandisers develop assortment strategies. To further develop the concept of VSA, one of their suggested additional research topics is using ARM to test performance of multiple delivery strategies in relation to VSA.

According to ARM, multiple delivery means an initial delivery and several additional deliveries based on re-estimation of POS data (Nuttle, King, & Hunter, 1991; Hunter, King, & Nuttle, 1992). Multiple delivery strategies have only been extensively applied to basic and staple goods (Kunz, 1996; Nuttle, King, & Hunter, 1991). This study used ARM to examine the possibility of employing multiple delivery strategies for fashion and seasonal goods and to evaluate the performance of multiple delivery strategies in relation to VSA. Ten and 20 weeks selling periods were selected to represent fashion and seasonal goods.

The research framework of this study was the Behavioral Theory of the Apparel Firm (Kunz, 1995) because this study is an extension of Rupe and Kunz's (in review) research. Two objectives were developed for this study. The first objective was to propose a model of merchandise replenishment process in the context of the Behavioral Theory of the Apparel

Firm. The second objective of this study was to evaluate the performance of multiple delivery strategies in relation to VSA for two selling periods. In terms of the first objective, the merchandise replenishment process was defined and a model of merchandise replenishment process was developed based on the literature review. This model delineates elements of the merchandise replenishment process, interactions among elements, and possible interactions among retailers and suppliers. It shows that all the elements of the merchandise replenishment process are interdependent. Any change or result of one element impacts on other elements. Merchandise planning and reorder planning play dominant roles in merchandise replenishment. These two elements receive information both inside and outside of the model, coordinate information into merchandise plans or reorder plans, and provide guidelines for ongoing interaction.

In addition, to be consistent with the concepts of the VSA (Rupe & Kunz, in review), volume per SKU for the initial delivery (VSID) was proposed to identify units of initial delivery allocated on the average for each SKU in an assortment. This concept facilitated the development of delivery strategies in relation to VSA and provided a foundation for data analysis based on ARM simulation data.

In terms of the second objective, data generated from ARM was analyzed in two stages. In the first stage, principle component factor analysis was used to identify prominent dimensions of performance measures when multiple delivery strategies were used. Nine performance measures were factored into two dimensions: 1) revenue and service (RS) and 2) inventory and profitability (IP). Both dimensions had similar weight for measuring the performance of assortments in relation to multiple delivery strategies.

In the second stage, performance dimensions derived from the first stage were used to test hypotheses. Three hypotheses were tested in relation to the second objective:

H 1. With the same selling period, the VSA, VSID, and FAD are not interdependent in their influence on performance of assortments.

H 2. FAD do not significantly affect performance of assortments with the same selling period, VSA, and VSID.

H 3. With the same selling period and VSA, there are no significant differences in performance of assortments between using single delivery strategy and multiple delivery strategies.

The first null hypothesis was tested by analysis of variance (ANOVA) procedures and was rejected. Different VSAs, VSIDs, and/or FAD significantly affected performance of assortments. This result supported the interrelationship among four elements of the proposed model of merchandise replenishment process: merchandise planning, reorder planning, placing initial orders, and placing reorders. Performance of assortments depended on combinations of the VSA, VSID, FAD.

The second null hypothesis was tested by ANOVA procedures and least significant difference (LSD) multiple comparisons. This hypothesis was rejected except when the VSID was nearly equal to the VSA. Additional deliveries did not affect performance of assortments when VSA and VSID were similar because the quantities of additional deliveries were very small. High VSID may not improve assortment performance even if additional deliveries were used.

For strategy combinations that were rejected by Hypothesis 2, LSD multiple comparisons were used to further identify FAD with the best performance of assortments. The result identified FAD at given levels of VSA and VSID that had the best performance. The results may provide quantitative guidelines for developing delivery strategies to improve performance of assortments.

The third null hypothesis was tested by T tests. The result of Hypothesis 3 indicated that multiple delivery strategies improved performance of assortments only when appropriate strategy combinations were used. Two characteristics related to delivery strategies were identified. First, multiple delivery strategies did not improve overall performance (OP) for fashion and seasonal goods with the 10 weeks selling period. It meant that multiple delivery strategies did not improve overall performance of assortments for seasonal and fashion goods in short selling periods. Second, the higher the VSID the fewer additional deliveries required to get better performance than single delivery. Higher VSID meant higher volume per SKU

on the average. The chance of stockouts is reduced. Few additional deliveries were required to get better performance than single delivery.

# IMPLICATIONS

## The proposed model of merchandise replenishment process in relation to Behavioral Theory of the Apparel Firm with quick response business systems

The proposed model is based on the following assumptions of behavioral theory with a QR construct:

- A firm is a coalition of individuals with some common goals.
- The coalition is made up of sub-coalitions of constituencies that conform to the functional areas of the specialization of the firm.
- Six constituencies perform all the business functions required for the operation of the apparel firm.
- Overall goals of the coalition are formulated by the executive constituency.
- The focus of the coalition is on the customer and satisfying the customer's needs within the limitations of the firm.
- The interrelationships among constituencies form the internal decision matrix for the firm.
- Time-based competition will change the firms decision-making priorities and measures of success.
- Agility will contribute to the ability of the firm to satisfy customer wants and needs.
- Partnering will provide information to optimize the ability to achieve the firm's goals. (Kunz, 1996, p. 15-16).

According to Kunz's (1996) behavioral theory with QR business systems, an apparel firm consists of quick response, merchandising, operations, marketing, finance, and executive management constituencies. Satisfying target customer wants and needs within the limitations of the firm is the central focus of decision making among six constituencies (Kunz, 1995). Both merchandising and operations constituencies take major responsibilities for replenishing merchandise to satisfy customer demand while considering the firm's limitations. Merchandisers plan, develop, and present product lines that satisfy customer demand.

Operations personnels manage human resources, physical facilities and equipment, and inventories to maximize efficiency and profitability of operations (Kunz, 1995).

The dark box in Figure 5 indicates the relationship between the proposed model of merchandise replenishment process and Kunz's (1996) Behavioral Theory of the Apparel Firm with QR business systems. The box overlaps the merchandising and operations constituencies because they cooperate with each other and with external coalitions regarding merchandise replenishment. The box overlaps the target market because POS data are the source of information for predicting future demand and determining the SKUs and quantities to reorder. Only part of the box overlaps the QR constituency because not all firms use the QR concepts to replenish merchandise. Some firms may still use the traditional methods. The proposed model may provide a framework for developing and testing research questions related to merchandise replenishment.

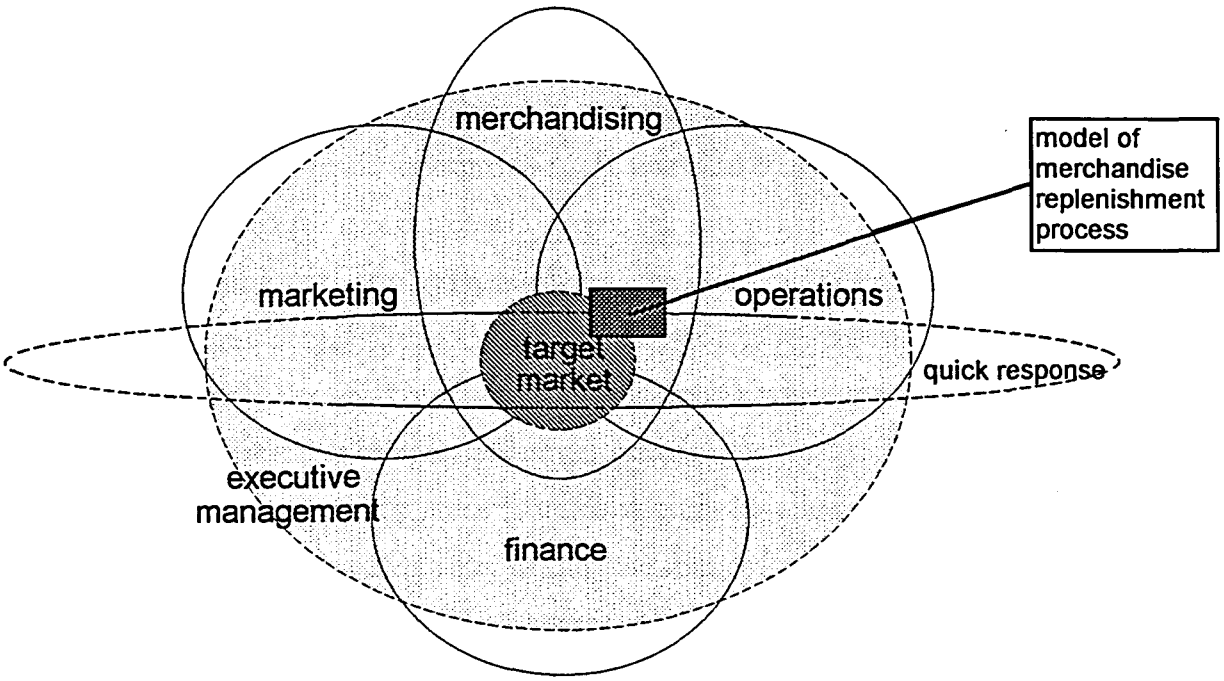



Figure 5. The proposed model of merchandise replenishment process to Behavioral Theory of the Apparel Firm operating with quick response systems.(Kunz, 1995; 1996).

**Multiple delivery strategies in relation to merchandise planning**

Merchandise planning along with appropriate delivery strategies is a major tool for achieving balanced assortments to satisfy customer's needs and wants (Kunz & Song, in review). Previous research (Hunter, King, & Nuttle, 1992; Nuttle, King, & Hunter, 1991) only indicated that frequently re-estimating customer demand and replenishing merchandise may be one way to increase stock turnover and reduce stockouts. This study identified two performance measures and quantitative guidelines for developing delivery strategies in fashion and seasonal goods with two selling periods.

According to simulation data, two dimensions of performance, revenue and service(RS) and inventory and profitability (IP), were identified from nine performance measures when multiple delivery strategies were used. RS meant revenues increased because of improved in-stock position. The fewer the stockouts the higher the revenues. IP meant the profitability of merchandising strategies increased because of reduced average inventory and residual inventory. The lower the average inventory and residual inventory the higher the profitability of merchandising strategies. Both dimensions had similar weight for measuring the performance of assortments in relation to multiple delivery strategies. A third performance measure, overall performance (OP), was used by averaging the sum of RS and IP. The results implicated that customer-oriented retailers may use RS as the appropriate performance measure, cost-oriented retailers may use IP as the appropriate performance measure, and others may use OP as the appropriate performance measure. Additional research may identify the weights of both factors in the real world and the combinations of weights in both factors that can get optimal performance.

Tables 15 and 17 present some quantitative guidelines that may be used for developing delivery strategies. Merchandisers may identify the volume per SKU for the assortment (VSA) and its selling period, select performance measures based on firms' positioning, and then refer to Tables 15 and 17 to determine appropriate delivery strategies. They may also use the Tables to negotiate the frequency of tabulating inventory and providing information to the merchandisers so better reorder strategies can be used.

Some general guidelines related to Table 17 include the following:

1) In relation to volume per SKU for the assortment (VSA),

- When the assortment is more diverse (VSA = 2) or diverse (VSA = 5), multiple delivery strategies can improve revenue and service (RS).
- When the assortment is diverse (VSA is 5 or below), multiple delivery strategies are unlikely to improve inventory and profitability (IP) or overall performance (OP).
- When the assortment is focused (VSA = 10), there is the best chance of using multiple delivery strategies to improve assortment performance compared to single delivery.

2) In relation to volume per SKU for the initial delivery (VSID),

- The higher the VSID the fewer additional deliveries required to get better performance than single delivery.
- When VSID is low, assortment performance for IP can be improved.
- When VSID is low or high (close to VSA), assortment performance for RS and OP can not be improved.

3) In relation to the length of selling period,

- Multiple delivery strategies do not improve OP for a 10 week selling period.
- Multiple delivery strategies are likely to improve OP for a 20 week selling period.

However, the results of this study were based on specified simulation scenarios and data; additional research is needed to verify findings by using real world data and different scenarios.

Based on the methods and results of this study, five additional research topics are proposed: First, is there any difference in assortment performance by using different re-estimation methods? Only one re-estimation method was tested for this study because only one re-estimation method is available in ARM. Additional research may use different re-estimation methods to develop multiple delivery strategies and compare the differences among them.

Second, is there any difference in assortment performance by using different timing of additional deliveries? Only one time schedule of additional deliveries was tested for this study. Additional research may use different timing of additional deliveries and compare the differences among them.

Third, can the results of this study apply to different customer arrival patterns and customer shopping behavior? In this study, the customer arrival pattern was based on the settings of ARM simulation. The probability of in-store shopping behavior was based on research findings of customers shopping behavior at Ramal (Song, 1996), an up-scale apparel specialty store. Additional research may use different settings to examine if the results of this study can be applied to different situations.

Fourth, is it possible to improve performance of assortments for fashion and seasonal goods with a 10 week selling period by using multiple delivery strategies with a shorter lead time or with different pricing strategies? The results of this study indicated that multiple delivery strategies did not improve overall performance of assortments for fashion and seasonal goods with a 10 week selling period. Two of the reasons may be that this study assumed the shortest lead time of 1 week and constant price for merchandise sold during a selling period. Additional research may identify the possibility of using shorter lead time and/or incorporating pricing strategies into multiple delivery strategies to improve performance of assortments in the short selling periods.

Finally, is there any difference in assortment performance by delivering a different quantity of SKUs in each delivery? For this study, all SKUs within an assortment were shipped at the first delivery; only assortment volume was manipulated to determine VSID. In the real world, retailers may only order part of the SKUs for the first delivery with remaining SKUs for the following deliveries. Additional research may manipulate number of SKUs and assortment volume to determine VSID and to test their performance.

# APPENDIX A. RESULTS OF LSD TESTS

Table A1. Results of LSD tests of performance for selected VSA, VSID, and FAD for the 10 week selling period.

| | | | | | VSA = 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 4 | -0.21489 | A | 6 | -0.9405 | A | 6 | -1.1933 | A |
| | 5 | -0.21696 | A | 5 | -1.0387 | A | 5 | -1.2557 | A |
| | 6 | -0.25275 | A | 2 | -1.0973 | A | 4 | -1.6438 | B |
| | 3 | -0.47933 | B | 4 | -1.4289 | B | 2 | -1.8647 | B |
| | 2 | -0,76738 | C | 3 | -1.5139 | B | 3 | -1.9932 | B |
| | 1 | -0.82385 | C | 1 | -1.8291 | C | 1 | -2.6530 | C |
| 2 | | | | 6 | -1.5845 | A | 6 | -0.9749 | A |
| | | | | 5 | -1.8671 | B | 5 | -1.3170 | A, B |
| | | | | 2 | -1.8817 | B | 2 | -1.3615 | A, B |
| | | | | 4 | -1.9463 | B | 4 | -1.4088 | B |
| | | | | 1 | -1.9588 | B, C | 3 | -1.6863 | B |
| | | | | 3 | -2.1804 | C | 1 | -1.7127 | B |

Table A1. (continued)

| | | | | | VSA = 5 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 4 | -0.9079 | A | 6 | 0.56450 | A | 6 | -0.6213 | A |
| | 5 | -1.1144 | A, B | 5 | 0.39138 | A, B | 4 | -0.6638 | A |
| | 6 | -1.1858 | A, B | 2 | 0.37364 | A, B | 5 | -0.7230 | A |
| | 3 | -1.2724 | A, B | 1 | 0.31324 | B, C | 3 | -1.1167 | B |
| | 1 | -1.9811 | C | 4 | 0.24406 | B, C | 1 | -1.6679 | C |
| | 2 | -2.1755 | C | 3 | 0.15574 | C | 2 | -1.8019 | C |
| 2 | 5 | 0.08229 | A | 6 | 0.3870 | A | 6 | 0.3674 | A |
| | 4 | -0.01505 | A | 5 | 0.2014 | A. B | 5 | 0.2837 | A |
| | 6 | -0.01957 | A | 4 | 0.1190 | B, C | 4 | 0.1039 | A, B |
| | 3 | -0.07293 | A | 2 | 0.0212 | B, C | 3 | -0.1591 | B, C |
| | 2 | -0.38884 | B | 1 | -0.0844 | C | 2 | -0.3676 | C |
| | 1 | -0.77644 | C | 3 | -0.0862 | C | 1 | -0.8609 | D |
| 3 | 5 | 0.52804 | A | 6 | 0.1433 | A | 6 | 0.6387 | A |
| | 4 | 0.52026 | A | 4 | -0.1256 | B | 4 | 0.3946 | A, B |
| | 6 | 0.49533 | A | 2 | -0.1361 | B | 5 | 0.3277 | A, B |
| | 3 | 0.43252 | A | 3 | -0.1635 | B | 3 | 0.2690 | A, B |
| | 2 | 0.16451 | B | 5 | -0.2003 | B | 2 | 0.0284 | B |
| | 1 | -0.15684 | C | 1 | -0.5095 | C | 1 | -0.6663 | C |
| 4 | 4 | 0.81848 | A | 6 | -0.2701 | A | | | |
| | 6 | 0.77538 | A | 2 | -0.4239 | A, B | | | |
| | 5 | 0.74288 | A | 3 | -0.4910 | B | | | |
| | 3 | 0.68688 | A | 1 | -0.5113 | B | | | |
| | 2 | 0.68629 | A | 5 | -0.5268 | B | | | |
| | 1 | 0.45740 | B | 4 | -0.6404 | B | | | |

Table A1. (continued)

| | | | | | VSA = 10 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 4 | -1.3984 | A | 6 | 1.33042 | A | 4 | -0.3682 | A |
| | 5 | -1.8144 | B | 4 | 1.03020 | B | 6 | -0.5431 | A, B |
| | 6 | -1.8735 | B | 5 | 1.02525 | B | 5 | -0.7891 | C, B |
| | 3 | -1.9303 | B | 2 | 0.81966 | C | 3 | -1.1471 | C |
| | 2 | -4.2119 | C | 3 | 0.78319 | C | 2 | -3.3922 | D |
| | 1 | -4.8658 | D | 1 | 0.72687 | C | 1 | -4.1389 | E |
| 2 | 5 | -0.34735 | A | 6 | 1025970 | A | 6 | 0.8247 | A |
| | 6 | -0.43504 | A | 5 | 1.07437 | B | 5 | 0.7270 | A |
| | 4 | -0.43719 | A | 4 | 1.05263 | B | 4 | 0.6154 | A, B |
| | 3 | -0.46946 | A | 1 | 1.01372 | B | 3 | 0.3459 | B |
| | 2 | -0.18364 | B | 2 | 0.82244 | C | 2 | -0.3612 | C |
| | 1 | -2.01089 | C | 3 | 0.81531 | C | 1 | -0.9972 | D |
| 3 | 5 | 0.30704 | A | 6 | 1.14862 | A | 5 | 1.2331 | A |
| | 4 | 0.12733 | B | 5 | 0.92602 | B | 6 | 1.1683 | A |
| | 6 | 0.01965 | B, C | 4 | 0.90778 | B | 4 | 1.0351 | A |
| | 3 | -0.07205 | C | 2 | 0.77537 | B, C | 3 | 0.5930 | B |
| | 2 | -0.59432 | D | 3 | 0.66509 | C | 2 | 0.1811 | C |
| | 1 | -0.78309 | E | 1 | 0.43441 | D | 1 | -0.3487 | D |
| 4 | 4 | 0.5752 | A | 6 | 1.02873 | A | 6 | 1.4646 | A |
| | 5 | 0.5117 | A, B | 4 | 0.80438 | B | 4 | 1.3796 | A |
| | 6 | 0.4359 | A, B | 5 | 0.77779 | B | 5 | 1.2895 | A |
| | 3 | 0.3110 | B | 3 | 0.68348 | B, C | 3 | 0.9945 | B |
| | 2 | 0.0086 | C | 2 | 0.56175 | C | 2 | 0.5703 | C |
| | 1 | -0.3134 | D | 1 | 0.28711 | D | 1 | -0.0263 | D |
| 5 | 6 | 0.65284 | A | 6 | 0.84618 | A | 6 | 1.4990 | A |
| | 5 | 0.64730 | A | 5 | 0.67715 | A, B | 5 | 1.3245 | A, B |
| | 4 | 0.57461 | A | 4 | 0.60902 | C, B | 4 | 1.1836 | B |
| | 3 | 0.54429 | A | 2 | 0.55724 | C, B | 3 | 1.0229 | C, B |
| | 2 | 0.22000 | B | 3 | 0.47864 | C | 2 | 0.7772 | C |
| | 1 | -0.08792 | C | 1 | 0.10674 | D | 1 | 0.0188 | D |

Table A1. (continued)

| | | | | | VSA = 10 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 6 | 6 | 0.80283 | A | 6 | 0.7045 | A | 6 | 1.5073 | A |
| | 5 | 0.75824 | A | 2 | 0.5664 | A, B | 5 | 1.3209 | A, B |
| | 4 | 0.73346 | A | 5 | 0.5626 | A, B | 4 | 1.2877 | A, B |
| | 3 | 0.70864 | A | 4 | 0.5543 | A, B | 3 | 1.1935 | A, B |
| | 2 | 0.46935 | B | 3 | 0.4848 | B | 2 | 1.0357 | B |
| | 1 | 0.24836 | C | 1 | 0.0424 | C | 1 | 0.2907 | C |
| 7 | 4 | 0.88479 | A | 6 | 0.5209 | A | 6 | 1.3839 | A |
| | 6 | 0.86303 | A, B | 2 | 0.4295 | A | 4 | 1.2548 | A |
| | 5 | 0.86092 | A, B | 4 | 0.3700 | A | 5 | 1.2277 | A |
| | 3 | 0.78347 | A, B | 5 | 0.3668 | A | 2 | 1.1123 | A |
| | 2 | 0.68272 | B | 3 | 0.3058 | A | 3 | 1.0893 | A |
| | 1 | 0.34484 | C | 1 | 0.0398 | B | 1 | 0.3847 | B |
| 8 | 4 | 0.9676 | A | | | | | | |
| | 5 | 0.9000 | A | | | | | | |
| | 6 | 0.8934 | A | | | | | | |
| | 3 | 0.8522 | A | | | | | | |
| | 2 | 0.7941 | A | | | | | | |
| | 1 | 0.5576 | B | | | | | | |

Table A1. (continued)

| | | | | | VSA = 20 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 2 | 3 | -1.1076 | A | 6 | 1.8068 | A | 6 | 0.3580 | A |
| | 5 | -1.2227 | A, B | 4 | 1.5520 | A, B | 3 | 0.3130 | A |
| | 6 | -1.4488 | B | 5 | 1.5171 | B | 5 | 0.2943 | A |
| | 4 | -1.4782 | B | 3 | 1.4206 | B | 4 | 0.0738 | A |
| | 2 | -2.7829 | C | 2 | 1.3055 | B | 2 | -1.4774 | B |
| | 1 | -5.7326 | D | 1 | 0.8479 | C | 1 | -4.8846 | C |
| 4 | 5 | 0.12207 | A | 6 | 1.66696 | A | 6 | 1.5527 | A |
| | 3 | -0.08961 | B | 5 | 1.42937 | B | 5 | 1.5514 | A |
| | 6 | -0.11427 | B | 1 | 1.28783 | B, C | 3 | 1.1780 | B |
| | 2 | -0.84366 | C | 3 | 1.26759 | C | 2 | 0.3369 | C |
| | 1 | -1.62070 | D | 2 | 1.18058 | C | 1 | -0.3329 | D |
| 6 | 5 | 0.6113 | A | 6 | 1.45968 | A | 5 | 2.0264 | A |
| | 4 | 0.5250 | A | 5 | 1.41503 | A | 6 | 1.9334 | A |
| | 6 | 0.4737 | A | 4 | 1.32389 | A, B | 4 | 1.8489 | A, B |
| | 3 | 0.3877 | A | 3 | 1.14307 | B | 3 | 1.5308 | B |
| | 2 | -0.1660 | B | 2 | 1.13860 | B | 2 | 0.9726 | C |
| | 1 | -0.3555 | E | 1 | 0.7013 | C | 1 | 0.3457 | D |
| 8 | 5 | 0.77039 | A | 6 | 1.33116 | A | 6 | 2.0503 | A |
| | 6 | 0.71915 | A, B | 5 | 1.20444 | A, B | 5 | 1.9748 | A |
| | 4 | 0.69117 | A, B | 4 | 1.16860 | A, B | 4 | 1.8598 | A, B |
| | 3 | 0.54957 | B | 3 | 1.06413 | B | 3 | 1.6137 | C, B |
| | 2 | 0.27336 | C | 2 | 1.03171 | B | 2 | 1.3051 | C |
| | 1 | -0.00388 | D | 1 | 0.52488 | C | 1 | 0.5210 | D |
| 10 | 4 | 0.8269 | A | 6 | 1.27054 | A | 6 | 2.0876 | A |
| | 6 | 0.8170 | A | 5 | 1.04280 | B | 4 | 1.8529 | A, B |
| | 5 | 0.8045 | A | 4 | 1.02597 | B | 5 | 1.8473 | A, B |
| | 3 | 0.7188 | A | 2 | 0.95674 | B | 3 | 1.6750 | B, C |
| | 2 | 0.4210 | B | 3 | 0.95614 | B | 2 | 1.3777 | C |
| | 1 | 0.3164 | B | 1 | 0.70210 | C | 1 | 1.0185 | D |

Table A1. (continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | VSA = 20 | | | | |
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 12 | 5 | 0.9330 | A | 6 | 1.07003 | A | 5 | 1.9523 | A |
| | 4 | 0.8875 | A, B | 5 | 1.01936 | A | 4 | 1.9323 | A, B |
| | 6 | 0.8623 | A, B | 4 | 0.95709 | A | 6 | 1.8446 | A, B |
| | 3 | 0.8445 | A, B | 2 | 0.92341 | A | 3 | 1.7594 | A, B |
| | 2 | 0.7041 | B | 3 | 0.91492 | A | 2 | 1.6275 | B |
| | 1 | 0.3942 | C | 1 | 0.61936 | B | 1 | 1.0136 | C |
| 14 | | | | | | | 6 | 1.9346 | A |
| | | | | | | | 4 | 1.9004 | A |
| | | | | | | | 2 | 1.7245 | A |
| | | | | | | | 3 | 1.6765 | A |
| | | | | | | | 5 | 1.6556 | A, B |
| | | | | | | | 1 | 1.2271 | B |
| 16 | 3 | 1.07541 | A | | | | 6 | 1.8361 | A |
| | 5 | 1.04572 | A | | | | 3 | 1.8269 | A |
| | 4 | 1.03523 | A | | | | 5 | 1.8179 | A |
| | 6 | 1.01914 | A | | | | 4 | 1.7443 | A |
| | 2 | 0.93568 | A | | | | 2 | 1.7125 | A |
| | 1 | 0.71889 | B | | | | 1 | 1.2553 | B |

Table A2. Results of LSD tests of performance for selected VSA, VSID, and FAD for the 20 week selling period.

| VSA = 2 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 6 | -0.20196 | A | 2 | -0.70693 | A | 3 | -1.3075 | A |
| | 10 | -0.31500 | B, A | 3 | -0.92927 | B | 5 | -1.3971 | A |
| | 5 | -0.32095 | B, A | 5 | -1.07613 | B, C | 6 | -1.4120 | A, B |
| | 9 | -0.32166 | B, A | 4 | -1.12032 | D, C | 9 | -1.4721 | A, B, C |
| | 3 | -0.37823 | B, A | 9 | -1.15048 | D, C | 4 | -1.5060 | A, B, C |
| | 4 | -0.38566 | B, C | 13 | -1.19426 | D, C | 10 | -1.5363 | A, B, C |
| | 8 | -0.51318 | C, D | 12 | -1.20652 | D, C | 2 | -1.7376 | B, C |
| | 7 | -0.54708 | C, D | 6 | -1.20999 | D, C | 7 | -1.7843 | D, C |
| | 11 | -0.57417 | D | 10 | -1.22133 | D, C | 12 | -1.7899 | D, C |
| | 12 | -0.58337 | D | 11 | -1.22489 | D, C | 11 | -1.7991 | D, C |
| | 13 | -0.88059 | E | 7 | -1.23717 | D, C | 8 | -1.8019 | D, C |
| | 1 | -0.95521 | E | 8 | -1.28868 | D | 13 | -2.0748 | D, C |
| | 2 | -1.03065 | E | 1 | -1.79694 | E | 1 | -2.7522 | E |
| 2 | | | | 13 | -1.6262 | A | 13 | -1.2575 | A |
| | | | | 2 | -1.6807 | A | 12 | -1.3740 | B, A |
| | | | | 12 | -1.7513 | B, A | 2 | -1.4146 | B, A |
| | | | | 7 | -1.7688 | B, A | 11 | -1.4361 | B, A |
| | | | | 11 | -1.8193 | B, A, C | 7 | -1.4566 | B, A |
| | | | | 3 | -1.9056 | B, D, C | 3 | -1.5710 | B, A |
| | | | | 4 | -1.9098 | B, D, C | 10 | -1.5719 | B, A |
| | | | | 6 | -1.9400 | B, D, C | 6 | -1.5765 | B, A |
| | | | | 5 | -1.9931 | D, C | 4 | -1.6121 | B, A |
| | | | | 10 | -1.9950 | D, C | 5 | -1.6946 | B, C |
| | | | | 1 | -2.0333 | D | 9 | -1.6979 | B, C |
| | | | | 9 | -2.0477 | D | 8 | -1.7556 | B, C |
| | | | | 8 | -2.0821 | D | 1 | -2.0450 | C |

Table A2. (continued)

| | | | | | VSA = 5 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 10 | -0.7405 | A | 3 | 0.76178 | A | 10 | -0.1694 | A |
| | 9 | -0.8926 | B, A | 2 | 0.71088 | B, A | 9 | -0.3734 | B, A |
| | 6 | -0.9139 | B, A | 4 | 0.59644 | B, C | 6 | -0.4302 | B, A, C |
| | 8 | -1.0265 | B, C | 10 | 0.57108 | B, C | 8 | -0.5459 | B, D, C |
| | 11 | -1.0816 | B, C, D | 5 | 0.54311 | D, C | 11 | -0.6878 | B, D, C |
| | 12 | -1.1755 | E, C, D | 13 | 0.53948 | D, C | 4 | -0.6959 | B, D, C |
| | 7 | -1.2737 | E, D | 1 | 0.52520 | D, C | 12 | -0.7315 | D, C |
| | 4 | -1.2924 | E, D | 9 | 0.51921 | D, C | 7 | -0.7547 | D, C |
| | 5 | -1.3747 | E, F | 7 | 0.51907 | D, C | 5 | -0.8316 | E, D |
| | 3 | -1.6026 | G, F | 6 | 0.48368 | D, C | 3 | -0.8409 | E, D |
| | 13 | -1.6750 | G | 8 | 0.48061 | D, C | 13 | -1.1355 | E |
| | 1 | -2.2930 | H | 12 | 0.44399 | D, C | 1 | -1.7677 | F |
| | 2 | -3.6106 | I | 11 | 0.39382 | D | 2 | -2.8997 | G |
| 2 | 10 | 0.21924 | A | 2 | 0.33702 | A | 6 | 0.2855 | A |
| | 6 | 0.17715 | B, A | 3 | 0.24418 | B, A | 4 | 0.2515 | A |
| | 9 | 0.14997 | B, A | 13 | 0.23318 | B, A, C | 13 | 0.2447 | A |
| | 8 | 0.04192 | B, A, C | 4 | 0.23073 | B, A, C | 10 | 0.2233 | A |
| | 12 | 0.02979 | B, A, C | 6 | 0.10838 | B, D, C | 9 | 0.1625 | A |
| | 4 | 0.02072 | B, A, C | 12 | 0.06169 | E, D, C | 3 | 0.1360 | B, A |
| | 13 | 0.01154 | B, C | 5 | 0.04738 | E, D | 12 | 0.0915 | B, A |
| | 5 | -0.01387 | B, C | 9 | 0.01249 | E, D | 5 | 0.0335 | B, A |
| | 3 | -0.10822 | C | 10 | 0.0041 | E, D | 8 | 0.0291 | B, A |
| | 2 | -0.53178 | D | 8 | -0.01280 | E, D | 2 | -0.1948 | B |
| | 1 | -0.86685 | E | 1 | -0.08845 | E | 1 | -0.9553 | C |

Table A2. (continued)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | VSA = 5 | | | | |
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 3 | 8 | 0.5281 | A | 2 | 0.10069 | A | 13 | 0.4221 | A |
| | 5 | 0.4762 | A | 13 | 0.00522 | B, A | 3 | 0.3330 | A |
| | 9 | 0.4712 | A | 3 | -0.00311 | B, A | 12 | 0.3238 | A |
| | 10 | 0.4704 | A | 4 | -0.11706 | B, C | 8 | 0.3024 | A |
| | 12 | 0.4626 | A | 12 | -0.13879 | B, C | 4 | 0.2632 | A |
| | 11 | 0.4568 | A | 7 | -0.17662 | B, C, D | 7 | 0.2558 | A |
| | 7 | 0.4325 | A | 8 | -0.22570 | C, D | 5 | 0.2194 | A |
| | 13 | 0.4169 | A | 5 | -0.25687 | C, D | 9 | 0.1874 | A |
| | 6 | 0.4077 | A | 9 | -0.28379 | C, D | 11 | 0.1592 | A |
| | 4 | 0.3802 | A | 6 | -0.29656 | C, D | 10 | 0.1300 | A |
| | 3 | 0.3362 | A | 11 | -0.29753 | C, D | 6 | 0.1112 | A |
| | 2 | -0.0023 | B | 10 | -0.34036 | D | 2 | 0.0984 | A |
| | 1 | -0.3753 | C | 1 | -0.68213 | E | 1 | -1.0575 | B |
| 4 | 6 | 0.7019 | A | 2 | -0.0789 | A | 13 | 0.3674 | A |
| | 12 | 0.6712 | A | 13 | -0.2843 | B, A | 2 | 0.3187 | B, A |
| | 8 | 0.6617 | A | 3 | -0.4080 | B, C | 12 | 0.2333 | B, A, C |
| | 13 | 0.6517 | A | 12 | -0.4378 | B, C, D | 3 | 0.1760 | B, A, C |
| | 7 | 0.6408 | A | 4 | -0.5356 | B, C, D | 7 | 0.0809 | B, A, C |
| | 11 | 0.6262 | B, A | 7 | -0.5599 | B, C, D | 6 | 0.0778 | B, A, C |
| | 10 | 0.6194 | B, A | 6 | -0.6341 | E, D | 8 | 0.0271 | B, A, C |
| | 9 | 0.6123 | B, A | 8 | -0.6346 | E, D | 4 | 0.0180 | B, A, C |
| | 5 | 0.5943 | B, A | 11 | -0.6662 | E | 11 | -0.0400 | B, A, C |
| | 3 | 0.5848 | B, A | 5 | -0.6952 | E | 10 | -0.0858 | B, C |
| | 4 | 0.5535 | B, A | 1 | -0.6981 | E | 9 | -0.0974 | C |
| | 2 | 0.3976 | B | 10 | -0.7052 | E | 5 | -0.1009 | C |
| | 1 | 0.1557 | C | 9 | -0.7098 | E | 1 | -0.5424 | D |

Table A2. (continued)

| VSA = 5 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 5 | | | | 2 | -0.5287 | A | | | |
| | | | | 13 | -0.7890 | B | | | |
| | | | | 3 | -0.7961 | B | | | |
| | | | | 12 | -0.8273 | B | | | |
| | | | | 7 | -0.8475 | B | | | |
| | | | | 4 | -0.9273 | C, B | | | |
| | | | | 5 | -0.9665 | C, B | | | |
| | | | | 1 | -0.9885 | C, B | | | |
| | | | | 10 | -1.0035 | C, B | | | |
| | | | | 11 | -1.0037 | C, B | | | |
| | | | | 6 | -1.0233 | C, B | | | |
| | | | | 8 | -1.1210 | C | | | |
| | | | | 9 | -1.1429 | C | | | |

Table A2. (continued)

| | | | | | VSA = 10 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 1 | 10 | -0.8444 | A | 9 | 1.37632 | A | 10 | 0.4787 | A |
| | 12 | -0.9526 | B, A | 12 | 1.33549 | A | 9 | 0.4068 | B, A |
| | 9 | -0.9695 | B, A | 10 | 1.32308 | B, A | 12 | 0.3829 | B, A |
| | 11 | -1.0892 | B, A | 3 | 1.28771 | B, A | 11 | 0.1647 | B, A, C |
| | 8 | -1.1230 | B, A | 8 | 1.28026 | B, A | 8 | 0.1572 | B, A, C |
| | 6 | -1.2151 | B, C | 13 | 1.27141 | B, A | 6 | 0.0112 | B, D, C |
| | 7 | -1.4617 | D, C | 4 | 1.25782 | B, A | 7 | -0.2237 | E, D, C |
| | 13 | -1.5664 | D | 11 | 1.25396 | B, A | 13 | -0.2950 | E, D |
| | 4 | -1.7304 | D | 7 | 1.23810 | B, A | 4 | -0.4726 | E |
| | 5 | -1.7315 | D | 6 | 1.22626 | B, A | 5 | -0.5676 | E |
| | 3 | -2.9558 | E | 5 | 1.16391 | B | 3 | -1.6680 | F |
| | 1 | -5.4122 | F | 1 | 0.77067 | C | 1 | -4.46415 | G |
| | 2 | -7.8737 | G | 2 | 0.57392 | D | 2 | -7.2998 | H |
| 2 | 11 | -0.08729 | A | | | | 11 | 1.0910 | A |
| | 10 | -0.10633 | A | | | | 10 | 0.9664 | B, A |
| | 9 | -0.15303 | B, A | | | | 13 | 0.9434 | B, A, C |
| | 8 | -0.22693 | B, A | | | | 8 | 0.9162 | B, A, C |
| | 6 | -0.23454 | B, A | | | | 9 | 0.9072 | B, D, A, C |
| | 13 | -0.32086 | B, C | | | | 6 | 0.7191 | B, D, A, C |
| | 7 | -0.45561 | D, C | | | | 7 | 0.6484 | B, D, C |
| | 5 | -0.54110 | D | | | | 4 | 0.6203 | D, E, C |
| | 4 | -0.58451 | D | | | | 5 | 0.3765 | D, E |
| | 3 | -0.93835 | .....E | | | | 3 | -0.9420 | E |
| | 2 | -2.20829 | F | | | | 2 | -1.1080 | F |
| | 1 | -2.26814 | F | | | | 1 | | F |

Table A2. (continued)

| | | | | | VSA = 10 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 3 | 9 | 0.40977 | A | 13 | 0.94748 | A | 7 | 1.2126 | A |
| | 8 | 0.40937 | A | 2 | 0.90043 | B, A | 13 | 1.2020 | A |
| | 10 | 0.40154 | A | 7 | 0.87527 | B, A | 8 | 1.1833 | A |
| | 12 | 0.36367 | B, A | 3 | 0.86709 | B, A | 12 | 1.1522 | B, A |
| | 11 | 0.35483 | B, A | 5 | 0.83921 | B, A, C | 6 | 1.1246 | B, A |
| | 6 | 0.34236 | B, A | 4 | 0.80214 | B, D, A, C | 9 | 1.0950 | B, A |
| | 7 | 0.33731 | B, A | 12 | 0.78850 | B, D, C | 10 | 1.0537 | B, A |
| | 13 | 0.25454 | B, A, C | 6 | 0.78222 | B, D, C | 11 | 1.0489 | B, A |
| | 5 | 0.18276 | B, C | 8 | 0.77397 | B, D, C | 5 | 1.0220 | B, A |
| | 4 | 0.08825 | C | 11 | 0.69410 | D, C | 4 | 0.8904 | B, C |
| | 3 | -0.20347 | D | 9 | 0.68525 | D, C | 3 | 0.6636 | C |
| | 1 | -0.72694 | E | 10 | 0.65218 | D | 2 | -0.0871 | D |
| | 2 | -0.98755 | F | 1 | 0.49622 | E | 1 | -0.2307 | D |
| 4 | 9 | 0.55710 | A | 2 | 0.06830 | A | 12 | 1.2468 | A |
| | 12 | 0.55668 | A | 13 | 0.74709 | B, A | 13 | 1.2339 | A |
| | 10 | 0.54887 | A | 7 | 0.70912 | B, A, C | 7 | 1.2254 | A |
| | 7 | 0.51626 | A | 12 | 0.69014 | B, A, C | 9 | 1.1150 | A |
| | 8 | 0.51010 | A | 4 | 0.65849 | B, C | 8 | 1.1060 | A |
| | 13 | 0.48677 | B, A | 5 | 0.61857 | B, C | 10 | 1.0876 | A |
| | 5 | 0.42758 | B, A | 8 | 0.59593 | B, C | 5 | 1.0461 | A |
| | 4 | 0.30484 | B | 9 | 0.55866 | C | 4 | 0.9633 | A |
| | 2 | -0.37772 | C | 10 | 0.53875 | C | 2 | 0.4906 | B |

Table A2. (continued)

| | | | | | VSA = 10 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 5 | 12 | 0.6719 | A | 2 | 0.86731 | A | 13 | 1.3496 | A |
| | 13 | 0.6530 | A | 13 | 0.69656 | B, A | 12 | 1.2550 | A |
| | 11 | 0.6500 | A | 3 | 0.62746 | B, C | 7 | 1.2086 | A |
| | 9 | 0.6272 | B, A | 4 | 0.59944 | B, C | 5 | 1.1526 | A |
| | 7 | 0.6118 | B, A | 7 | 0.59682 | B, C | 11 | 1.1250 | A |
| | 10 | 0.6110 | B, A | 12 | 0.58312 | B, C, D | 4 | 1.1160 | A |
| | 5 | 0.5763 | B, A | 5 | 0.57631 | B, C, D | 9 | 1.0807 | A |
| | 4 | 0.5166 | B, A | 11 | 0.47502 | C, D | 3 | 1.0397 | A |
| | 3 | 0.4166 | B | 9 | 0.45348 | C, D | 10 | 1.0138 | A |
| | 2 | 0.1413 | C | 10 | 0.40286 | D | 2 | 1.0086 | A |
| | 1 | -0.0163 | C | 1 | 0.09026 | E | 1 | 0.0740 | B |
| 6 | 9 | 0.73992 | A | 2 | 0.7044 | A | 13 | 1.2391 | A |
| | 10 | 0.73477 | A | 3 | 0.5894 | B, A | 3 | 1.1941 | A |
| | 6 | 0.70182 | A | 13 | 0.5505 | B, A, C | 7 | 1.1744 | A |
| | 8 | 0.70040 | A | 7 | 0.4889 | B, D, C | 4 | 1.0818 | A |
| | 13 | 0.68865 | A | 4 | 0.4791 | B, E, D, C | 5 | 1.0594 | A |
| | 7 | 0.68550 | A | 5 | 0.3751 | F, E, D, C | 2 | 1.0585 | A |
| | 5 | 0.68432 | A | 11 | 0.3453 | F, E, D, C | 8 | 1.0455 | A |
| | 11 | 0.65896 | A | 8 | 0.3451 | F, E, D, C | 6 | 1.0278 | A |
| | 3 | 0.60468 | A | 6 | 0.3260 | F, E, D | 10 | 1.0092 | A |
| | 4 | 0.60273 | A | 10 | 0.2744 | F, E | 9 | 1.0064 | A |
| | 2 | 0.35410 | B | 9 | 0.2665 | F | 11 | 1.0043 | A |
| | 1 | 0.03690 | C | 1 | -0.0572 | G | 1 | -0.0203 | B |

Table A2. (continued)

| VSA = 10 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 7 | 12 | 0.78606 | A | 2 | 0.56454 | A | 13 | 1.1422 | A |
| | 11 | 0.77471 | A | 3 | 0.41858 | B, A | 2 | 1.1407 | A |
| | 6 | 0.76268 | B, A | 13 | 0.37967 | B, A | 3 | 0.1341 | A |
| | 13 | 0.76250 | B, A | 12 | 0.33440 | B, C | 12 | 1.1205 | A |
| | 9 | 0.75569 | B, A | 11 | 0.25999 | B, C, D | 11 | 1.0347 | A |
| | 10 | 0.75145 | B, A | 10 | 0.17250 | E, C, D | 10 | 0.9240 | A |
| | 3 | 0.71552 | B, A | 6 | 0.11116 | E, F, D | 6 | 0.8738 | A |
| | 2 | 0.57619 | B | 9 | 0.06711 | E, F | 9 | 0.8228 | A |
| | 1 | 0.29838 | C | 1 | -0.05331 | F | 1 | 0.2451 | B |
| 8 | 12 | 0.8305 | A | 2 | 0.4582 | A | 2 | 1.1853 | A |
| | 5 | 0.8270 | A | 3 | 0.2865 | B, A | 3 | 1.0629 | B, A |
| | 13 | 0.8171 | A | 13 | 0.2435 | B, C | 13 | 1.0606 | B, A |
| | 7 | 0.8123 | A | 4 | 0.1709 | B, C | 12 | 0.9831 | B, A |
| | 6 | 0.8113 | A | 12 | 0.1527 | B, C, D | 4 | 0.9555 | B, A |
| | 9 | 0.8092 | A | 7 | 0.1066 | B, C, D | 7 | 0.9188 | B, A |
| | 8 | 0.7973 | A | 11 | 0.0982 | B, C, D | 5 | 0.9098 | B, A |
| | 11 | 0.7906 | A | 5 | 0.0829 | B, C, D | 11 | 0.8888 | B, A |
| | 4 | 0.7846 | A | 6 | 0.0764 | C, D | 6 | 0.8878 | B, A |
| | 3 | 0.7763 | A | 8 | -0.0352 | E, D | 9 | 0.7669 | B |
| | 2 | 0.7271 | A | 9 | -0.0423 | E, D | 8 | 0.7621 | B |
| | 1 | 0.3753 | B | 1 | -0.2005 | E | 1 | 0.1747 | C |

Table A2. (continued)

| VSA = 10 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 9 | | | | 2 | 0.2337 | A | | | |
| | | | | 3 | 0.0480 | B, A | | | |
| | | | | 13 | 0.0356 | B, A, C | | | |
| | | | | 7 | -0.0820 | B, D, C | | | |
| | | | | 11 | -0.1184 | B, D, C | | | |
| | | | | 4 | -0.1310 | B, D, C | | | |
| | | | | 9 | -0.1686 | B, D, C | | | |
| | | | | 6 | -0.1816 | D, C | | | |
| | | | | 10 | -0.1914 | D | | | |
| | | | | 8 | -0.2092 | D | | | |
| | | | | 5 | -0.2295 | D | | | |
| | | | | 1 | -0.2489 | D | | | |

Table A2. (continued)

| VSA = 20 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 2 | 11 | -0.0974 | A | 13 | 1.95847 | A | 11 | 1.6657 | A |
| | 10 | -0.1454 | A | 7 | 1.84699 | B, A | 13 | 1.6491 | A |
| | 9 | -0.1489 | B, A | 4 | 1.81273 | B, A, C | 9 | 1.6364 | A |
| | 8 | -0.2926 | B, A | 9 | 1.78529 | B, C | 10 | 1.5461 | A |
| | 13 | -0.3094 | B, A | 8 | 1.78390 | B, C | 8 | 1.4913 | A |
| | 6 | -0.3274 | B, A | 11 | 1.76308 | B, C | 7 | 1.3833 | A |
| | 7 | -0.4637 | B, C | 3 | 1.74898 | B, C | 6 | 1.3750 | A |
| | 5 | -0.7320 | D, C | 6 | 1.70238 | B, C | 5 | 0.9332 | B |
| | 4 | -1.0092 | D | 10 | 1.69154 | B, C | 4 | 0.8036 | B |
| | 3 | -2.2127 | E | 5 | 1.66520 | C | 3 | -0.4637 | C |
| | 2 | -5.5096 | F | 2 | 1.43356 | D | 2 | -4.0760 | D |
| | 1 | -6.2861 | G | 1 | 0.82556 | E | 1 | -0.54605 | E |
| 4 | 10 | 0.4125 | A | | | | 12 | 1.9625 | A |
| | 12 | 0.3496 | B, A | | | | 10 | 1.9151 | B, A |
| | 11 | 0.3286 | B, A | | | | 13 | 1.8852 | B, A, C |
| | 9 | 0.2753 | B, A | | | | 11 | 1.8041 | B, A, C |
| | 6 | 0.2258 | B, A, C | | | | 6 | 1.7823 | B, A, C |
| | 13 | 0.1946 | B, A, C | | | | 9 | 1.7814 | B, A, C |
| | 7 | 0.1819 | B, A, C | | | | 7 | 1.7748 | B, A, C |
| | 8 | 0.1776 | B, C | | | | 8 | 1.6779 | B, A, C |
| | 5 | 0.0297 | D, C | | | | 5 | 1.5652 | B, C |
| | 4 | -0.0970 | D | | | | 4 | 1.5241 | D, C |
| | 3 | -0.4405 | E | | | | 3 | 1.1767 | D |
| | 1 | -1.9841 | F | | | | 1 | -0.5233 | E |
| | 2 | -2.3640 | G | | | | 2 | -0.7680 | E |

Table A2. (continued)

| VSA = 20 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 6 | 11 | 0.7406 | A | 13 | 1.33090 | A | 13 | 2.0371 | A |
| | 10 | 0.7320 | A | 2 | 1.26642 | B, A | 11 | 1.9059 | B, A |
| | 13 | 0.7062 | B, A | 3 | 1.25598 | B, A | 6 | 1.8422 | B, A |
| | 6 | 0.6785 | B, A | 7 | 1.22356 | B, A, C | 10 | 1.8095 | B, A |
| | 5 | 0.5703 | B, A | 5 | 1.21365 | B, A, C | 5 | 1.7840 | B, A |
| | 7 | 0.5595 | B, A | 4 | 1.19554 | B, A, C | 7 | 1.7831 | B, A |
| | 4 | 0.4835 | B | 11 | 1.16537 | B, C | 4 | 1.6790 | B, C |
| | 3 | 0.1738 | C | 6 | 1.16373 | B, C | 3 | 1.4298 | C |
| | 1 | -0.3269 | D | 10 | 1.07753 | C | 2 | 0.6845 | D |
| | 2 | -0.5819 | E | 1 | 0.90580 | D | 1 | 0.5789 | D |
| 8 | 8 | 0.8111 | A | 3 | 1.17183 | A | 8 | 1.8767 | A |
| | 12 | 0.7782 | A | 2 | 1.16982 | A | 13 | 1.8665 | A |
| | 10 | 0.7645 | B, A | 13 | 1.2535 | B, A | 12 | 1.8121 | A |
| | 6 | 0.7421 | B, A | 7 | 1.11605 | B, A | 5 | 1.7918 | A |
| | 13 | 0.7411 | B, A | 4 | 1.10386 | B, A | 6 | 1.7803 | A |
| | 9 | 0.7106 | B, A | 5 | 1.08458 | B, A, C | 7 | 1.7749 | A |
| | 5 | 0.7073 | B, A | 8 | 1.06561 | B, A, C | 4 | 1.7407 | A |
| | 7 | 0.6589 | B, A | 6 | 1.03823 | B, A, C | 10 | 1.7327 | A |
| | 4 | 0.6368 | B, A | 12 | 1.03390 | B, A, C | 3 | 1.7027 | A |
| | 3 | 0.5309 | B | 10 | 0.96820 | B, C | 9 | 1.6168 | A |
| | 2 | 0.0325 | C | 9 | 0.90618 | D, C | 2 | 1.2023 | B |
| | 1 | 0.0274 | C | 1 | 0.77589 | D | 1 | 0.8033 | C |

Table A2. (continued)

| | | | | | VSA = 20 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 10 | 12 | 0.8661 | A | 2 | 1.11980 | A | 5 | 1.8626 | A |
| | 5 | 0.8381 | A | 3 | 1.07075 | B, A | 12 | 1.8347 | A |
| | 10 | 0.8205 | A | 4 | 1.03364 | B, A, C | 4 | 1.8285 | A |
| | 6 | 0.8191 | A | 5 | 1.02453 | B, D, C | 7 | 1.7965 | A |
| | 13 | 0.8052 | A | 7 | 0.99963 | E, B, D, A, C | 3 | 1.7735 | A |
| | 7 | 0.7968 | A | 12 | 0.96863 | E, B, D, A, C | 13 | 1.7558 | A |
| | 4 | 0.7949 | A | 13 | 0.95064 | E, B, D, C | 6 | 1.7410 | B, A |
| | 11 | 0.7773 | A | 6 | 0.92196 | E, B, D, C | 10 | 1.7009 | B, A |
| | 8 | 0.7761 | A | 10 | 0.88403 | E, D, C | 8 | 1.6474 | B, A |
| | 3 | 0.7028 | A | 8 | 0.87130 | E D | 11 | 1.6292 | B, A |
| | 2 | 0.3371 | B | 11 | 0.85185 | E | 2 | 1.4569 | B |
| | 1 | 0.2605 | B | 1 | 0.58613 | F | 1 | 0.8466 | C |
| 12 | 5 | 0.86134 | A | 2 | 1.00183 | A | 3 | 1.7763 | A |
| | 12 | 0.85841 | A | 3 | 0.97360 | B, A | 13 | 1.7661 | A |
| | 13 | 0.85141 | A | 13 | 0.91472 | B, A | 5 | 1.7263 | A |
| | 9 | 0.84977 | A | 4 | 0.86665 | B, A, C | 4 | 1.6992 | A |
| | 8 | 0.84609 | A | 5 | 0.86498 | B, A, C | 12 | 1.6713 | A |
| | 11 | 0.83701 | A | 12 | 0.81287 | B, D, C | 8 | 1.6455 | A |
| | 4 | 0.83250 | A | 8 | 0.79943 | B, D, C | 2 | 1.6349 | A |
| | 10 | 0.81649 | B, A | 11 | 0.77625 | B, D, C | 11 | 1.6133 | A |
| | 6 | 0.80938 | B, A | 6 | 0.77328 | D, C | 6 | 1.5827 | A |
| | 3 | 0.80269 | B, A | 9 | 0.71893 | D | 9 | 1.5677 | A |
| | 2 | 0.63303 | B | 10 | 0.71794 | D | 10 | 1.5344 | A |
| | 1 | 0.39697 | C | 1 | 0.41778 | E | 1 | 0.8147 | B |

Table A2. (continued)

| | | | | VSA = 20 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 14 | 7 | 0.9120 | A | 2 | 0.91681 | A | 3 | 1.7202 | A |
| | 10 | 0.9065 | A | 3 | 0.84849 | B, A | 7 | 1.6718 | A |
| | 8 | 0.8954 | A | 7 | 0.75981 | B, A, C | 2 | 1.6554 | A |
| | 9 | 0.8921 | A | 5 | 0.75340 | B, D, C | 5 | 1.6441 | A |
| | 5 | 0.8907 | A | 13 | 0.71277 | B, E, D, C | 13 | 1.5827 | A |
| | 12 | 0.8867 | A | 4 | 0.69506 | F, E, D, C | 4 | 1.5512 | A |
| | 3 | 0.8717 | A | 12 | 0.66001 | E, D, C | 12 | 1.5467 | A |
| | 13 | 0.8699 | A | 6 | 0.65256 | E, D, C | 10 | 1.5289 | A |
| | 11 | 0.8684 | A | 10 | 0.62232 | E, D, C | 6 | 1.5181 | A |
| | 6 | 0.8656 | A | 8 | 0.59339 | E, D | 8 | 1.4887 | A |
| | 4 | 0.8561 | A | 9 | 0.59222 | E | 9 | 1.4844 | A |
| | 2 | 0.7385 | A | 11 | 0.58109 | F | 11 | 1.4495 | A |
| | 1 | 0.4575 | B | 1 | 0.35009 | E | 1 | 0.8076 | B |
| 16 | | | | 2 | 0.76063 | A | 3 | 1.6398 | A |
| | | | | 3 | 0.71897 | B, A | 2 | 1.5963 | A |
| | | | | 7 | 0.57666 | B, A, C | 7 | 1.4859 | A |
| | | | | 5 | 0.56754 | B, C | 5 | 1.4851 | A |
| | | | | 12 | 0.55969 | B, C | 6 | 1.4836 | A |
| | | | | 4 | 0.55301 | B, C | 12 | 1.4659 | A |
| | | | | 6 | 0.53863 | B, C | 4 | 1.4574 | A |
| | | | | 11 | 0.48062 | D, C | 10 | 1.4203 | A |
| | | | | 8 | 0.47795 | D, C | 9 | 1.4176 | A |
| | | | | 10 | 0.46636 | D, C | 11 | 1.4111 | A |
| | | | | 9 | 0.46425 | D, C | 8 | 1.4043 | A |
| | | | | 1 | 0.31790 | D | 1 | 0.9062 | B |

Table A2. (continued)

| VSA = 20 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VSID | FAD | RS | LSD | FAD | IP | LSD | FAD | OP | LSD |
| 18 | | | | 2 | 0.65384 | A | | | |
| | | | | 3 | 0.48845 | B, A | | | |
| | | | | 13 | 0.45885 | B | | | |
| | | | | 12 | 0.41473 | B, C | | | |
| | | | | 4 | 0.40014 | B, C, D | | | |
| | | | | 5 | 0.38096 | B, C, D | | | |
| | | | | 11 | 0.37934 | B, C, D | | | |
| | | | | 7 | 0.36713 | B, C, D | | | |
| | | | | 6 | 0.33265 | B, C, D | | | |
| | | | | 8 | 0.33252 | B, C, D | | | |
| | | | | 10 | 0.32252 | B, C, D | | | |
| | | | | 9 | 0.25813 | C, D | | | |
| | | | | 1 | 0.22259 | D | | | |

# APPENDIX B. PERFORMANCE OF SINGLE DELIVERY FOR 4 LEVELS OF VSA FOR TWO SELLING PERIODS

| | The 10 week selling period | | | The 20 week selling period | | |
|---|---|---|---|---|---|---|
| VSA | RS | IP | OP | RS | IP | OP |
| 2 | -0.50481 | -0.63858 | -1.14339 | -0.78562 | -0.84407 | -1.62970 |
| 5 | 0.06176 | 0.10090 | 0.16266 | -0.14622 | -0.08602 | -0.23224 |
| 10 | 0.45121 | 0.65601 | 1.10722 | 0.23671 | 0.41014 | 0.64685 |
| 20 | 0.66394 | 0.92003 | 1.58398 | 0.50285 | 0.72550 | 1.22835 |

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