The Design of a Distribution Center with Value Added Operations

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Chapter 1

Introduction

1.1 Distribution Centers

The American Heritage Dictionary describes a warehouse as "a place in which goods or merchandise are stored." A distribution center (DC) facilitates the movement of goods from producer to consumer. Therefore, a DC could be defined as a warehouse with a dynamic system used to perform other tasks [1]. We often use the terms "distribution center" and "warehouse" interchangeably throughout the course of this study. This is due to the fact that we focus on the warehouse portion of the distribution center.

There are several functional areas that work must flow through in a DC. They are described as follows:

Shipping/Receiving — This is where incoming shipments of products are received, and finished orders are sent. For the purpose of our analysis this is where all our orders begin and end. Shipping and receiving can be considered as a single department or as two separate ones.

Reserve Department — This is where full cases are stored before being shipped out as orders are sent to the forward department for replenishment. Shelving usually goes from the floor to the ceiling, utilizing space to the maximum extent possible.

Our study focuses on manual retrieval for this area. This is accomplished with the assistance of order-picker trucks or some other vehicle capable of raising and lowering the driver/operator to the appropriate level and carrying multiple loads of the product at the same time.

Forward Department — The forward department is comprised of flow racks that store smaller quantities of cases that are convenient for orderpickers to retrieve items. Flow racks in the forward department are typically no taller than 6'. The forward department can be used (to a limited extent) as a storage area, however due to the 6' height restriction, a large portion of the upper space in the warehouse is not used. A particular set of locations is dedicated to a single product type, and similar product types are usually grouped together. Our study assumes that orders are picked manually.

Value Added Department — This is where all the physical changes to individual products are performed. Examples of value added operations include the assembly of items from individual parts (electronics, automobile parts, etc.) and the modification of existing items (printing, sewing, temperature treatment, etc.).

Figure 1.1 presents a layout of a DC with the functional areas described above. It should be noted that the receiving and shipping departments in Figure 1.1 are separate. The forward department has also been located near the value added department and the shipping department to reduce travel distances.

1.2 Value Added Operations

For the purpose of this study, we focus on distribution centers that handle both value added (VA) and no-value added (NVA) products. A DC that services VA operations in addition to its normal activities faces a design problem: how to configure the forward/reserve departments for both of its operations. VA products require some sort of physical change to occur at the DC, while NVA products are shipped without any handling other than order

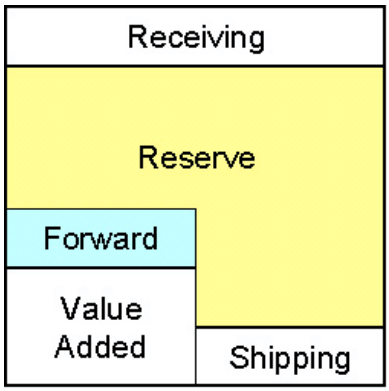

Figure 1.1: Example of a DC Layout.

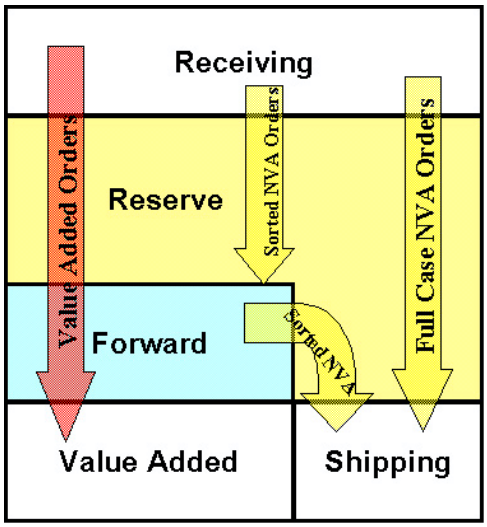

Figure 1.2: Flow of VA and NVA Products Through a Warehouse.

sortation. A DC that handles both VA and NVA products has at least two different sets of product flows within the same facility. Figure 1.2 shows how the different product types travel through the warehouse. It is important to note that VA orders must travel through all of the major areas of the DC, while full case orders can go from the reserve department directly to shipping, bypassing the forward and value added departments entirely. This difference in order characteristics greatly impacts the facility's operational requirements.

1.3 Problem Motivation

This study is motivated by an internship at Cross Creek Apparel, Inc.'s main distribution center in Mt. Airy, NC. The distribution center receives cases of garments from both domestic and overseas sewing plants, and ships orders to customers at different locations. Cases are similar in size, varying by product manufacturer. The DC fills both VA and NVA orders. Cross Creek Apparel, Inc.'s product breakdown is as follows:

Prepack (No-Value Added) — Full cases are pulled from the storage racks and sent directly to the shipping department. This is a large segment of the DC's business. Customers for prepack orders are usually distributors who break down the full cases after they are received and distribute the garments as necessary.

Sorted (No-Value Added) — These orders require garments to be picked, sorted, and taken to the shipping department. Cases and partial cases are retrieved manually and taken to an automatic sorter that sorts the garments into the correct orders. The garments are then packed and conveyed to shipping.

Decoration (Value Added) — These orders require garments to be picked, sorted, and taken to the decoration department. Usually garments are embroidered, fitted with a price ticket, poly-bagged, ironed, and repacked in the decoration department. After orders are decorated, they are sent to shipping. Customers for value added orders are usually golf pro shops.

Any changes in the balance between product demands requires Cross Creek to re-evaluate the layout of their DC. Recently, a potential increase in the number of value added activities raised the question as to how they should best layout their warehouse to service orders. Of particular interest is the picking and replenishment operations performed in the forward and reserve departments. Cross Creeks's design problem forms the basis for this study. We

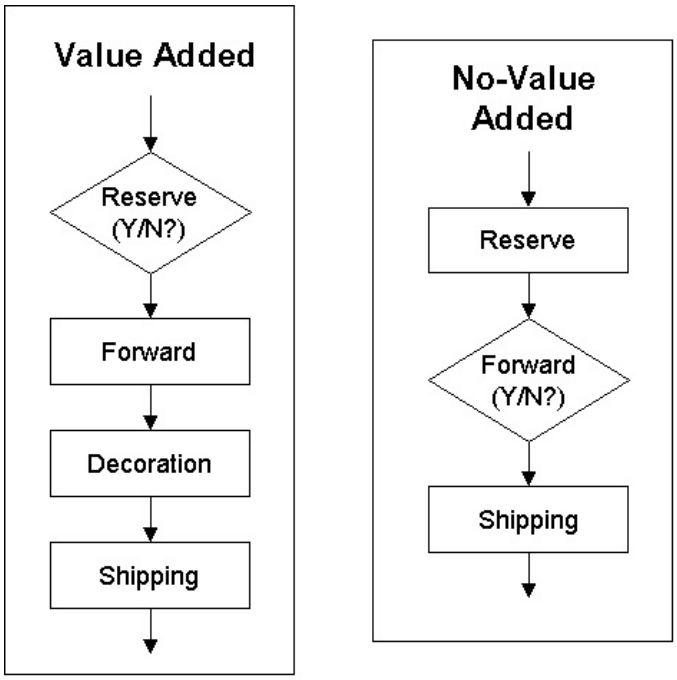

Figure 1.3: VA and NVA Product Flow.

also believe many other companies face this design problem, although their value added operations would not be the same if they were not in the apparel industry.

1.4 Problem Statement

We study the design of a distribution center that fills both VA and NVA orders. Figure 1.3 gives the path taken by the VA orders (e.g., decoration) and NVA orders (e.g., sorted, full case). Diamonds represent non-mandatory stages in the flow of the product. If there are small quantities of a product required only for VA orders, it may not be necessary to store cases of that product in the reserve department. If a product is only required for full case orders, no space should be allocated for it in the forward department. In these situations the cases would never be delivered to the department.

Since VA products require a forward department, and NVA products require a reserve department, we assume that both departments are included in the facility. Our focus then is

on the decision of how to design the facility to efficiently service these two types of products.

The design of a distribution center with VA operations presents the following question: Should a DC separate the reserve departments for the value added and no-value added products? This decision determines the optimum configuration of the reserve department, based on predefined operating characteristics, and adjustable parameters. Ideally, we would like to maximize our space utilization, while minimizing replenishment times. Unfortunately, these goals are in conflict with each other, and a final solution requires a tradeoff between the two. We examine the three options illustrated in Figure 1.4 (department areas are not shown to scale):

Two Separate Reserve Departments — This option separates the reserve department into VA and NVA areas. It is believed that this plan reduces putaway and replenishment costs due to shorter retrieval times. This storage plan requires more careful planning of inventory levels, and has a lower cube utilization, resulting in more overall space.

Single Reserve Department — This option utilizes space better, but has higher replenishment times. Planning requirements are also less under this option.

Hybrid Reserve Department — This option defines three reserve departments: a value added area, a no-value added area, and a hybrid area. The goal of this storage plan is to achieve both the higher space utilization of the single reserve department plan and the lower replenishment times of the two separate reserve department plan. Cases are pulled from the hybrid area of the reserve department to fulfill both VA and NVA orders, although it is preferred to pull these orders from their respective storage areas. Therefore, a decision is required as to the stocking levels of each hybrid item over the three areas of the reserve department.

The options depicted in Figure 1.4 only consider the operations in the reserve department(s). A fixed number of operators perform storage and replenishment/order fulfillment tasks.

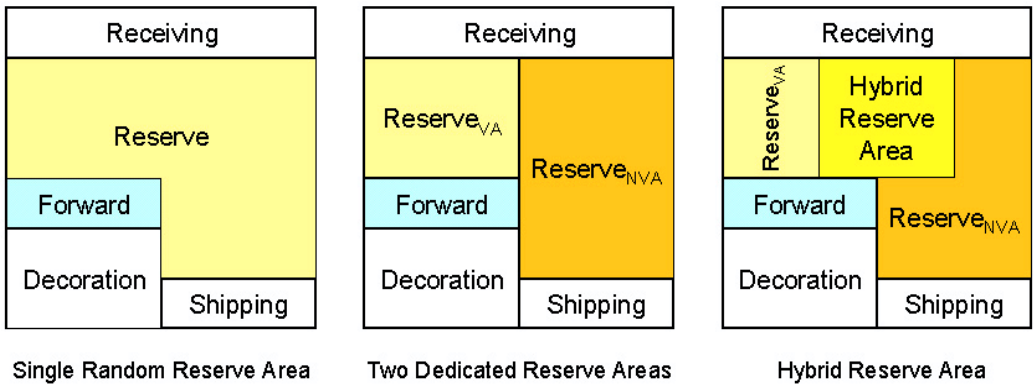

Figure 1.4: Reserve Department Organization Options.

Destinations include the forward department for replenishment and the shipping area for order fulfillment. A key question is whether or not to dedicate operators to the different reserve departments.

In addition to analyzing the reserve department, we must also consider the forward department in our study, with a similar research question to answer. Should a DC create a hybrid area to store cases common to both NVA and VA orders? For the purpose of this study we examine the two options illustrated in Figure 1.5 (department areas are not shown to scale):

Two Separate Forward Departments — This option completely separates the forward department into VA and NVA areas. Any items common to both NVA and VA items are stored in each area. It is believed that this plan reduces picking costs due to shorter retrieval times. However, this storage plan requires the maximum amount of floorspace.

Hybrid Forward Department — This option defines three areas in the forward department: a value added area, a no-value added area, and a hybrid area. The goal of this storage plan is to achieve lower floorspace requirements than the separate plan, while still maintaining low picking times. Items can be pulled from the hybrid area of the forward department to fulfill both NVA and VA orders, although it is preferred to pull these orders from their respective storage areas. Only items required by both NVA

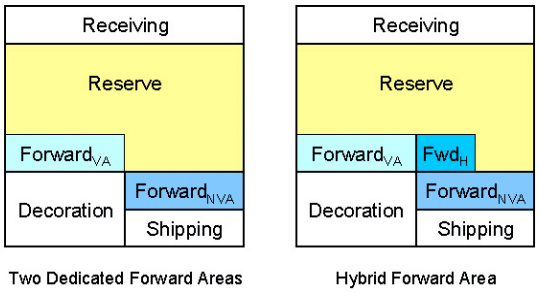

Figure 1.5: Forward Department Organization Options.

and VA orders should be stored in the hybrid area (as it increases travel distance to their respective destinations).

The options depicted in Figure 1.5 only consider the operations in the forward department(s). Orderpickers send VA orders to the decoration area and NVA orders to the sorter or shipping area for order fulfillment.

Based on the two research questions above, one of the six potential solutions enumerated in Figure 1.6 is selected. The outlines in Figure 1.6 are not to scale.

1.5 Thesis Outline

The remainder of this study is broken into seven chapters. Chapter 2 reviews the literature regarding warehouse design problems, routing and sequencing, and storage policies. Chapter 3 presents an overview of our problem. A small example problem is employed throughout Chapters 4 and 5 to illustrate our methodologies. Chapter 4 examines the reserve department methodology. Chapter 5 examines the forward department methodology. Chapter 6 presents additional example problems. Conclusions and areas for future research are presented in Chapter 7.

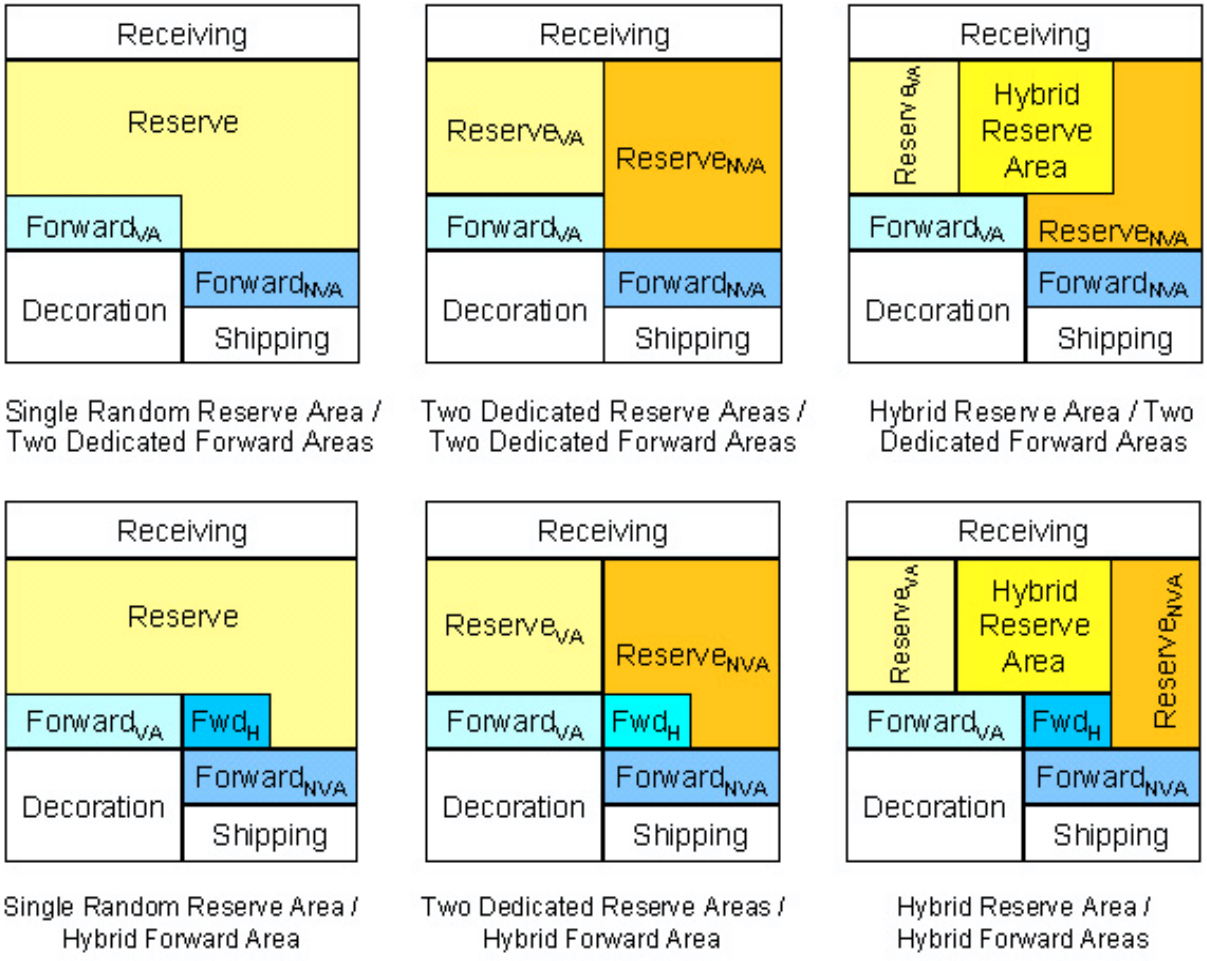

Figure 1.6: Six Potential Solutions.

Chapter 2

Literature Review

Warehouse and distribution center design has been the topic of many publications in the research literature. Rouwenhorst *et al.* [26] propose three different ways in which to view a warehouse in their recent literature review on warehouse design and control:

1. Process point of view — The flow of product through a warehouse is divided into several distinct processes. The receiving process looks at the way products arrive at a warehouse. The storage process looks at the way items are stored in a warehouse. This may consist of both a forward and reserve department (as in our study).

2. Resource point of view — This view focuses on all the means, equipment, and personnel required to operate the warehouse. Resources for warehouses include the storage unit, storage system, computer systems, and personnel.

3. Organizational point of view — Organization involves the planning and control issues required to run the warehouse. The decision to use separate forward and reserve departments for a given set of product types is organizational in nature.

Rouwenhorst *et al.* [26] also defines three levels of warehouse design problems: strategic, tactical, and operational.

1. Strategic problems — Strategic problems have the longest impact and are often the most costly of the three types of decisions. The two main types of strategic problems are the design of the process flow, and the selection of the type of warehousing system.

2. Tactical problems — Decisions at the tactical level are typically based on the outcome of the strategic decisions. For this reason they are shorter in scope, and have a smaller impact than the strategic decisions. Tactical decisions typically involve facility layout, organizational issues, dimensions of resources, and quantity of employees.

3. Operational problems — Operational decisions have the shortest scope (usually less than one year), and the lowest financial impact on the warehouse. Operational decisions faced by a warehouse might include the assignment of tasks to personnel, the locating of new products in storage, pick sequencing, etc.

The decisions addressed by this study are tactical in nature. The division of the forward/reserve departments to service different product types requires changes to be made in the layout of the warehouse. This suggests a time frame that is long enough to be tactical. However, this decision is not at a high enough level to consider it strategic. A strategic decision might be to open an additional warehouse to service value added operations. This would be outside the scope of our study.

Our study requires that we review literature on three subjects: warehouse design problems, routing and sequencing, and storage policies.

1. Warehouse Design Problems — Rouwenhorst *et al.* [26] defines a warehouse design problem as a cluster of decisions that are not guaranteed to give an optimal solution when optimized individually. We focus on literature relating to warehouse layout. This type of problem is typically considered to be tactical in nature.

2. Routing and Sequencing — There are three types of routing and sequencing problems studied in relation to warehouses: unit-load retrieval operations, orderpicking opera-

tions, and carousel operations. We focus on orderpicking operations, as they provide a method of evaluation for our study.

3. Storage Policies — In the storage process items are transported to the storage system and allocated to storage locations. Literature in this area focuses on several storage policies. Dedicated storage prescribes particular locations for each item to be stored. Random storage policies allow the operator to locate items at their discretion. Class based storage allocates zones to specific product groups, often based upon their turnover rate.

2.1 Warehouse Design Problems

Bassan *et al.* [2] and Berry [3] analyze the layout of a warehouse and provide models to determine the optimal dimensions of the layout to satisfy specific goals. Bassan *et al.* [2] examines the relationship between warehouse layout design and the total cost of item movement and construction. They focus on comparing alternative shelf arrangements to obtain optimal warehouse layouts. Comparisons were performed using three types of costs: internal handling costs, costs associated with warehouse area, and costs proportional to the building perimeter.

Berry [3] examines two types of layouts and derives equations for their dimensioning. Ten factors were considered in arriving at the layouts, and it is shown that different types of layouts are affected by different factors. The goal of dimensioning can be to minimize material handling distance or space utilization. Berry [3] uses a set of computer programs to provide numerical solutions to the layout problem.

Rosenblatt and Roll [24] develop a search procedure that combines analytical optimization and simulation techniques to find a global optimal solution for a specific formulation of the warehouse model. In this formulation three types of costs are considered: costs associated with initial investment, shortage costs, and costs associated with the storage policy. It is

assumed that arrival, composition, and retrieval distributions as well as approximate cost models are known.

Rosenblatt and Roll [25] also present a study that examines the required capacity of a warehouse in terms of its deviation from the nominal capacity requirement (NCR). A simulation model was employed to measure the relationship between warehouse capacity and various parameters. Based on the data gathered the authors conclude that deviation in the required capacity is mainly affected by the number of items stored, ordering quantity, and average issues of items per day.

Bozer [4, pp. 367–375] provides a brief analysis of multiple aisle walk and pick systems. Although the focus of [4] is the design of automated orderpicking systems, Bozer derives equations to find the optimum values for bay length and total number of aisles when other system characteristics are known. The analysis was limited to those cases where the unit load pick life (the number of picks that can be made from the unit load before it has to be replenished) increases linearly with the unit load size.

Pandit and Palekar [21] present a queuing theoretic model of a rectangular warehouse with an automated multi-vehicle material handling system to study the effect of warehouse design on response time. Response time is defined as the time taken by the material handling system to serve the order from the moment the order arrives at the input/output point until the vehicle returns to back to the door for another order. In other words, response time is the sum of the time an order spends waiting for a vehicle to become available and the time spent retrieving the order. The districting (partitioning) of the warehouse into service zones is the major design consideration. Automated guided vehicles (AGVs) are then dedicated to the individual zones. The study shows that response time decreases when the warehouse is districted into service zones. The study also presents a procedure for determining the optimal door location in a zone. Doors represent the input/output points for orders.

Frazelle *et al.* [10] incorporate a heuristic developed by Hackman and Rosenblatt [16] into a framework for determining the optimal size of the forward department. The costs in the

model for orderpicking in the forward department and replenishing are related to the size of the forward department. Frazelle *et al.* [10] present a case study where they project a 20% savings on labor cost by re-sizing the forward department down to 32% of its original size and by re-allocating the products among the forward and reserve departments.

As can be seen in the papers above, studies in warehouse design have focused on the dimensioning of a warehouse layout, or arrangement of aisles within the warehouse. With the exception of Frazelle *et al.* [10], little has been done to relate forward and reserve departments in one model, or design the forward/reserve departments for different product flows. Thus, we conclude that there is room for research in this area of warehouse design.

2.2 Routing and Sequencing

Ratliff and Rosenthal [22] and Goetschalckx and Ratliff [12] have both studied the multiple-stop traveling salesman problem and how it relates to orderpicking. They have worked to develop polynomial time algorithms to optimally route a picker through a rectangular warehouse. Ratliff and Rosenthal [22] convert the warehouse layout into a graph representation. Included in the graph representation are the shipping location, order items, and the end of aisles. The algorithm then finds the minimum length tour subgraph by considering each aisle in sequence. A tour is then constructed from the minimum length tour subgraph (using a procedure developed by the authors). This method allows the picker to reverse direction in an aisle.

Goetschalckx and Ratliff [12] examine the situation where items are stored in a wide aisle. Items must be manually retrieved from both sides and deposited in a vehicle, that travels the center line of the aisle. The picker stops the vehicle, picks and loads cases of items onto the vehicle and then drives to the next stop. An algorithm is presented to determine the optimal number and location of stops and to specify the items to be picked at each stop.

De Koster and van der Poort [8] extend the polynomial algorithm of Ratliff and Rosenthal

[22] to find orderpicking routes with a minimal length for both the situations of a central depot (I/O point) or decentralized depositing. Decentralized depositing is the situation where orderpicking trucks can pick up and deposit pallets at the head of every aisle without returning to the depot.

Goetschalckx and Ratliff [13] develop an efficient algorithm for orderpicking that produces policies that yield up to a 30% savings in travel time over commonly used policies. This paper looks at the situation where the aisle width is such that an operator cannot reach items on both sides without changing position. This causes the picker to cross the aisle one or more times. There are four major types of picking policies examined in this paper: traversal, split traversal, return, and split return.

A traversal policy enters at one end of an aisle, and exits at the other. A split traversal policy is a traversal policy that enters both ends of the aisle. A return policy enters and exits at the same end of the aisle. A split return policy is a return policy that enters from both ends of the aisle.

The traversal heuristic was compared with optimal solution procedure of Ratliff and Rosenthal [22]. In addition to the optimum traversal and optimum return policies, this procedure requires an optimum split traversal and an optimum split return policy in each aisle. This experiment contained two factors: order density and number of aisles. The heuristic generated travel distances that were 8% worse than the optimal travel distances on the average. The authors concluded that the optimum picking algorithm of Ratliff and Rosenthal [22] is worthwhile only when the number of aisles is very small (5 or less) or the order density is low (7% or less) [13]. In other cases, the improvement of the optimal over the traversal policy is very small.

Hall [17] developed algorithms to relate warehouse attributes to expected travel distance. Hall examines four major routing strategies in his paper: traversal, midpoint, largest gap, and "optimal" routing, all for random storage.

1. Traversal Strategy — As presented by [13] the traversal strategy is the simplest, and assumes that the worker travels the entire length of any aisle entered. This strategy tends to be preferred when the number of picks per aisle is greater than 3.8 [17].

2. Midpoint Strategy — The midpoint strategy divides the warehouse into two halves, with picks being accessed from either side. The midpoint strategy is a practical alternative to the traversal strategy when aisles tend to not contain more than one pick.

3. Largest Gap Strategy — The largest gap strategy is an improvement over the midpoint, with the picker traveling as far as the largest gap between picks.

4. "Optimal" Routing — The "optimal" routing is a hybrid of the traversal and the largest gap strategy. For the optimal routing the operator can either enter and exit from the same side, omitting the largest gap, or enter and exit from opposite sides and traverse the entire aisle. This minimizes the lateral distance traveled by the operator. Unfortunately, minimizing the lateral distance for a given aisle does not necessarily provide the shortest route length. After crossing through one aisle the operator may be at the wrong side of the next aisle. This requires some backtracking to occur.

Hall [17] assumes a vertical aisle structure with aisles running perpendicular to the warehouse front–end for all of his analyses.

Caron *et al.* [5] evaluates and compares the expected travel distances for traversal and return strategies in a warehouse. Items are assigned to storage location based on the ratio of order frequency to required space (cube-per-order index or COI). Caron *et al.* [5] develops analytical models that relate expected travel distance to the COI–based ABC curve, the number of picks per order, and the number, length, and width of aisles. An aisle structure that has two columns of aisles running horizontally is used for all analyses. Caron *et al.* [5] concludes that the return policy outperforms the traversal policy only when there are a low number of average picks per aisle (< 1). The ABC curve was found to play only a secondary role in the choice of the best routing policy.

Quite a bit of research has been done with regard to routing and sequencing in a warehouse. We have chosen to focus on papers dealing with routing an operator through a warehouse. In addition to these papers, much has been published on the subject of routing and sequencing for automated storage and retrieval systems (AS/RS). We have chosen not to include these in our literature review, as they are not applicable to our problem. In general, our study utilizes the results from existing routing and sequencing research in our overall DC design problem and does not develop new results in this area.

2.3 Storage Policies

Hausman *et al.* [18] and Goetschalckx and Ratliff [14] examine dedicated versus random storage of pallets. Hausman *et al.* [18] compares the operating performance of three storage assignment rules: random assignment, full turnover-based assignment, and class-based turnover assignment. Random assignment is not really random, but is based on the observation that placing a pallet in the closest open location distributes the pallets approximately randomly. Full turnover-based assignment dedicates pallets to storage locations based on their level of turnover. Class-based turnover assignment divides products into classes based on turnover. Pallets are then assigned to a class of storage based on their turnover volume and closest open location is utilized in each case.

Goetschalckx and Ratliff [14] introduce the concept of duration-of-stay for individual loads as a storage policy. Simulation results are provided that compare travel times for dedicated storage, random storage, turnover-based storage classes, and duration-of-stay-based storage classes. For perfectly balanced inputs and outputs the authors show that the optimal shared storage policy is to store the unit loads based on their duration-of-stay in the system. When the inputs and outputs are not balanced, simulation results [14] indicate that travel time is reduced by approximately 25% when compared with a dedicated storage policy. The authors comment that more studies must be performed with respect to the implementation of duration-of-stay storage policies.

Goetschalckx and Ratliff [15] evaluate storage policies for block storage through an analytical study. Two competing objectives are common in block stacking. First, available floor area should be used as efficiently as possible to maximize the space utilization of the warehouse. On the other hand, the cost for storing and retrieving items from the warehouse should be kept to a minimum. This study is concerned primarily with space utilization. The main issue affecting space utilization in block stacking systems is lane depth.

It is shown that the optimal lane depths follow a triangular pattern [15]. Five heuristics are presented for the case when a single product is stored in the warehouse: the pattern heuristic, equal heuristic, continuous equal heuristic, triangle heuristic, and the 1-lane and Q-lanes heuristic. Based on solution quality and required computational effort all the heuristics proved equivalent. The study went on to consider lane depths for multiple products. An efficient block stacking layout will most likely contain different lane depths, and unit loads of the same batch will go into lanes of different depths [15].

Jarvis and McDowell [19] propose a heuristic for the storage policy in a conventional warehouse. This heuristic provides a method for locating product in an orderpicking warehouse such that average orderpicking time is minimized. This is also called item slotting. The total distance traveled for any order is comprised of the distance traveled in aisles, and the distance traveled across aisles. In-aisle distance is minimized by grouping the set of products with the lowest demand in an aisle, the set of products with the next lowest demand in an aisle, and so on, so that the products with the highest demand are grouped in an aisle. Cross aisle travel will be minimized by assigning the least frequently picked products to the most distant aisle, the next most frequently picked items to the next most distant aisle, and so on until the most frequently picked items are assigned to the nearest aisle. These theories do not hold for the non-symmetric warehouse case (i.e., the dock is not located in the middle of the rows). Heuristics are developed for the non-symmetric warehouse case which are based on properties of the optimal solution.

Roll and Rosenblatt [23] analyze the effect that different storage policies have on warehouse

size using simulation. The paper introduces several important definitions used to characterize warehouses.

- **Extent of randomness** for storage assignment is the ratio of zone storage capacity to total warehouse capacity. For completely random storage, the extent of randomness is 1. In grouped storage where no randomness is allowed, by definition, the extent of randomness would be 0.

- **Nominal capacity requirements (NCR)** is the product of the average throughput by the average storage time per pallet. The NCR is the lower bound on the required warehouse capacity for the storage of all pallets under fully deterministic conditions and when perfect planning is possible.

- **Normalized Warehouse Size** is the ratio between actual warehouse capacity and the corresponding NCR. For completely random storage, and keeping the overflow within 1% of the NCR, a warehouse with capacity of 1.20 NCR is needed. If grouped storage is preferred, capacity should be increased to about 1.25 NCR. This statement assumes minimal (1%) overflow.

- **Overflow Factor** is the ratio of pallets to be stored outside the warehouse and the NCR.

It was found that variations in shipment size had the strongest influence on the overflow of the warehouse. Storage zone size seemed to have little effect on the required warehouse size needed to maintain a particular overflow level.

Van den Berg *et al.* [30] were the first to distinguish between replenishments that take place during busy and idle periods in the forward-reserve problem. The authors present a knapsack-based heuristic that attempts to find an allocation of products to the forward department that minimizes the total expected amount of orderpicking and replenishing time. The paper compares the heuristic with procedures that are popular in practice and indicates significant labor-savings are possible.

Van den Berg and Sharp [29] propose a procedure based on linear programming for product allocation in a warehouse consisting of a forward and reserve department, to minimize orderpicking and replenishment costs. The solution defines a framework for assignment of incoming loads to storage areas. Results show that major time savings are possible by permitting orderpicking from the reserve department for some products. Both the situation of orderpicking with idle periods and without idle periods is examined. This paper addresses the decision represented in Figure 1.2 shown earlier.

Malmborg [20] presents a model to analyze tradeoffs between space requirements and retrieval efficiency associated with dedicated and randomized storage policies. His model considers the space reductions associated with randomized storage in estimating item retrieval costs. It is shown that randomized storage can actually yield lower average retrieval costs than dedicated storage when the level of variation in retrievals demand for items is below a critical value. This paper is of particular interest due to his method for considering space requirements for alternative storage policies.

We focus on warehouses that employ manual orderpicking in the forward department. However, studies have been performed for the case where orderpicking in the forward department is automated. Bozer [4] treats the problem of splitting a pallet rack into an upper reserve department and a lower forward department. The author assumes a Chebyshev travel metric and a fixed pick life for all unit loads in the forward department. He shows when a separate reserve department is justified. The principal trade-off being that as the amount of stock assigned to the picking area is increased, the picker output will decrease. This is due to an increase in picking area size. Bozer also addresses the problem of determining which products to put in the forward department.

Hackman and Rosenblatt [16] address the replenishment issue for the forward/reserve department problem for cases when automated storage and retrieval systems (AS/RS) are employed. The AS/RS is assumed to be replenished when its internal stock reaches zero, and the reserve department is assumed to have unlimited capacity. The main focus of their

study is to determine which products to locate in the forward department, and how much space to allocate for each of these products. The objective of the study is to minimize the total costs for orderpicking and replenishing.

Research in the area of warehouse storage policies focuses primarily on the assignment of items to locations to minimize either warehouse size or orderpicking and replenishment costs. With the exception of Van den Berg and Sharp [29], the focus of these papers is typically product allocation rather than the dedication of forward/reserve departments to specific product types. The papers in this area (particularly Malmborg [20]) have provided us with valuable insight on how to size a warehouse based on historical demand.

2.4 Summary

Our study focuses on the design of forward and reserve departments for both NVA and VA products. As was concluded by Berry [3], the layout that maximizes space utilization is different from one that minimizes material handling distance. In order to evaluate the tradeoff between space utilization and material handling distance, we use methods developed in the papers discussed above.

Malmborg [20] presents a model to analyze tradeoffs between space requirements and retrieval efficiency associated with dedicated and randomized storage policies. This paper is of particular interest due to his method for considering space requirements for alternative storage policies. Malmborg [20] relates space requirements to the maximum inventory level for a given set of products over a period of time. This space requirement can be used to calculate warehouse area for a potential solution.

Hall [17] and Caron *et al.* [5] both developed algorithms to relate warehouse attributes to expected travel distance with random storage. Hall examines four major routing strategies in his paper: Traversal, Midpoint, Largest Gap, and Optimal Routing. Caron *et al.* [5] evaluates and compares the expected travel distances for traversal and return strategies in

a warehouse with a horizontal aisle configuration. The work of both Hall [17] and Caron *et al.* [5] is critical to this study as we use algorithms to form the foundation for evaluating different scenarios. Both papers provided insight into warehouse operations that was critical to the development of the methodologies presented in this paper.

Chapter 3

Problem Overview

This study focuses on how to best layout a warehouse to service both NVA and VA orders. We are faced with a tradeoff between space utilization (facility costs) and replenishment times (labor costs). Ideally, we would like to maximize our space utilization, while minimizing replenishment times. Unfortunately, these goals are in conflict with each other, and a final solution requires a tradeoff between the two.

The warehouse in the example problem has both forward and reserve departments. We assume that aisles run perpendicular to the front end of the warehouse, and aisle width is negligible for both departments. Items are received and stored in cases of like size and style.

3.1 Notation

The following notation is used throughout our study. We denote the reserve department as r when necessary in our notation and the forward department as f.

Parameters

C_z^l = annual cost of labor for department z (\$/operator)

C_z^a = annual cost of floorspace area for department z (\$/ft^2)

N_z = number of picks in a tour for department z (picks/tour)

Λ_z^i = demand for item i (for $i = 1, ..., P$) in department z (cases/year)

Y = capacity of an operator (hours/year)

v_z = operator velocity (ft/hour)

Variables

D_z = expected tour length for department z (ft/tour)

L_z = amount of labor required for department z (operators/year)

A_z = floorspace area required for department z (ft^2)

TC_z = total cost for department z ($/year)

3.2 Tradeoff Analysis

We have derived the following combined objective with the assistance of Cross Creek Apparel, Inc. to evaluate the tradeoff between space utilization (facility costs) and replenishment times (labor costs):

$$TC_z = C_z^a A_z + C_z^l L_z, \tag{3.1}$$

where L_z can be calculated with the following:

$$L_z = \frac{\sum_{i=1}^{P} \Lambda_z^i / N_z}{\left\lceil \left(\frac{v_z}{D_z} \right) \cdot Y \right\rceil}. \tag{3.2}$$

The values for floorspace and labor cost (C_z^a and C_z^l) can be determined using historical values. These values vary by department, and can be difficult to quantify in some cases. Values for floorspace area required (A_z) and labor required (L_z) vary based on the department and layout being analyzed. The labor required (L_z) for a warehouse is dependent upon the expected tour length (D_z). Methods for analyzing a warehouse and determining values for

A_z and D_z are presented in Chapters 4 and 5. Since operators can be hired on an hourly basis in most cases, we will allow fractional values for L_z in later chapters. On the other hand, we determine space requirement values, A_z, based on typical layouts requiring an integer number of equal length rows across each department.

3.3 Reserve Department Analysis

Our values for floorspace area required for the reserve department (A_r) and labor required for the reserve department (L_r) are based on the decision of whether or not to separate the reserve departments for the value added and no-value added products. This decision determines the optimum configuration of the reserve department based on our tradeoff between space utilization and replenishment times. For the purpose of this study, we examine the three options illustrated in Figure 1.4:

Two Separate Reserve Departments — This option separates the reserve department into VA and NVA reserve departments. This plan reduces putaway and replenishment costs due to shorter retrieval times. This storage plan requires more careful planning of inventory levels, and has a lower cube utilization, resulting in more overall space.

Single Reserve Department — This option utilizes space better, but has a higher replenishment time. Planning requirements are also less under this option.

Hybrid Reserve Department — This option defines three reserve departments: a value added reserve department, a no-value added reserve department, and a hybrid reserve department. The goal of this storage plan is to achieve both the higher space utilization of the single reserve department plan and the lower replenishment times of the two dedicated reserve department plan. Cases can be pulled from the hybrid reserve department to fulfill both VA and NVA orders, although it is preferred to pull these orders from their respective storage areas. Therefore, a decision is required as to the stocking levels of each hybrid item over the three reserve departments.

In the reserve department, cases are typically stored in the closest open location at the time. Given that cases are pulled in a stochastic manner, the closest open location's distribution appears uniform over the department [17]. We assume that items are stored randomly in the reserve department. Methods for analyzing a reserve department and an example problem are presented in Chapter 4.

3.4 Forward Department Analysis

In addition to analyzing the reserve department, we also consider the forward department in our study, with a similar question to answer. Should a DC create a hybrid area for the forward department to store cases common to both NVA and VA orders? Our values for floorspace area required for the forward department (A_f) and labor required for the forward department (L_f) are based on this decision. We examine the two options illustrated in Figure 1.5:

Two Separate Forward Departments — This option completely separates the forward department into VA and NVA sections. Any items common to both NVA and VA items are stored in each section. This plan reduces picking costs due to shorter retrieval times. However, this storage plan requires the maximum amount of floorspace.

Hybrid Forward Department — This option defines three forward departments: a value added forward department, a no-value added forward department, and a hybrid forward department. The goal of this storage plan is to achieve lower floorspace requirements than the separate plan, while still maintaining low picking times. Items can be pulled from the hybrid forward department to fulfill both NVA and VA orders, although it is preferred to pull these orders from their respective storage areas. Only items required by both NVA and VA should be stored in the hybrid area (as it increases travel distance to their respective destinations).

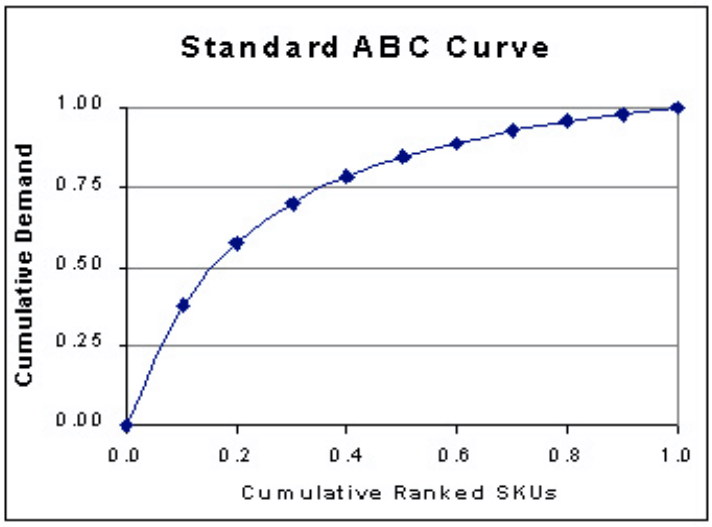

Figure 3.1: Example of a Standard ABC curve (70/30).

DCs dedicate particular locations to each stock-keeping unit (SKU) in the forward department. In addition, DCs tend to organize the forward department so that like items are near each other. In the apparel industry, garments are typically grouped by size, style, or color. In general, all industries use slotting algorithms in the forward depaartment to take advantage of the inter-item correlations to reduce travel distances. Slotting algorithms are based on the ABC curve for the items stored by the warehouse. A standard ABC curve plots the cumulative fraction of SKUs ranked by turnover against the cumulative fraction of demand for these items. Figure 4.5 presents a standard ABC curve with a 70/30 distribution of items (30% of the SKUs account for 70% of the demand). This slotting of items in the forward department causes the distribution of cases to not be uniform. Methods for analyzing a forward department and an example problem are presented in Chapter 5.

3.5 Routing Policies

In this section we examine three methods for routing an operator through N points. These methods were presented by Hall [17].

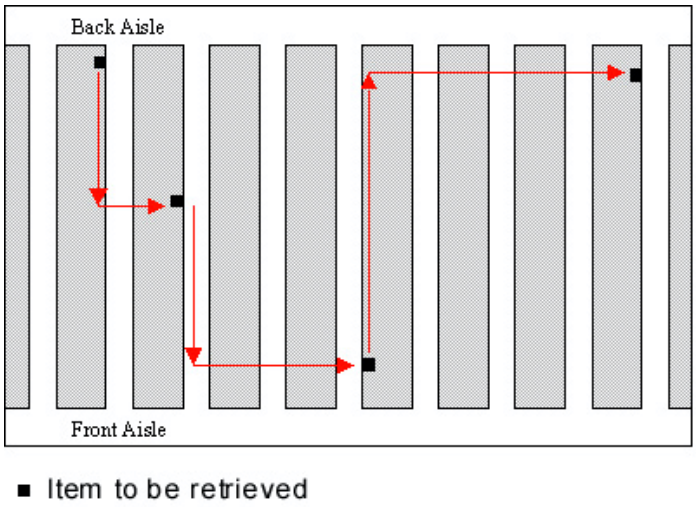

Figure 3.2: Illustration of Travel Assumed in the Shortest Cycle Algorithm.

3.5.1 Shortest Cycle

The shortest cycle algorithm gives the expected length of the shortest cycle through N points over a region of area A. This calculation does not consider aisle length, and is only presented as a tool for quick analysis. Figure 3.2 illustrates how the shortest cycle algorithm would route a picker through a series of points in a warehouse.

3.5.2 Traversal Strategy

The traversal strategy assumes that the picker travels the entire length of any aisle containing at least one pick. Aisles are served in order from left to right or right to left. Figure 4.4 illustrates how the traversal strategy would route a picker through a series of points in a warehouse with a vertical aisle structure. This algorithm considers aisle structure.

3.5.3 "Optimal" Strategy

The "optimal" strategy is a combination of the traversal strategy and the largest gap strategy. The largest gap strategy has the operator follow a return policy in which he/she will return

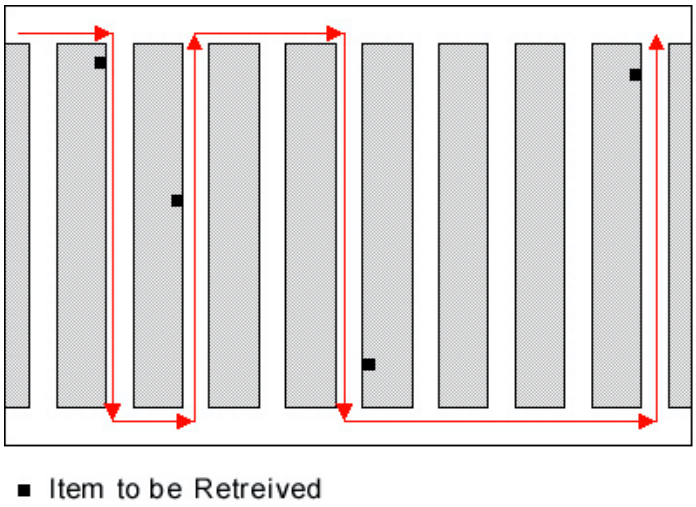

Figure 3.3: Illustration of Travel Assumed in the Traversal Strategy.

from the same side of the aisle that they entered. The operator enters the aisle as far as the "largest gap" before heading back to the side entered from. A gap represents the separation between any two adjacent picks, between the first pick and the front aisle, or between the last pick and the back aisle. The largest gap is the portion of the aisle not traversed by the operator.

For the "optimal" strategy the operator can either enter and exit from the same side, omitting the largest gap, or enter and exit from opposite sides and traverse the entire aisle. This minimizes the lateral distance traveled by the operator. Unfortunately, minimizing the lateral distance for a given aisle does not necessarily provide the shortest route length. After crossing through one aisle the operator may be at the wrong side of the next aisle. This requires some backtracking to occur.

Figure 3.4 gives a simple example of how an operator would be routed using the "optimal" strategy in a warehouse with a vertical aisle structure. It should be noted that the shortest route is not taken between the second and third picks in this route. While it is shorter to return to the aisle entered from for the second pick, this puts us on the wrong side of the aisle for the third pick. Overall it would be short to traverse the whole aisle after the second

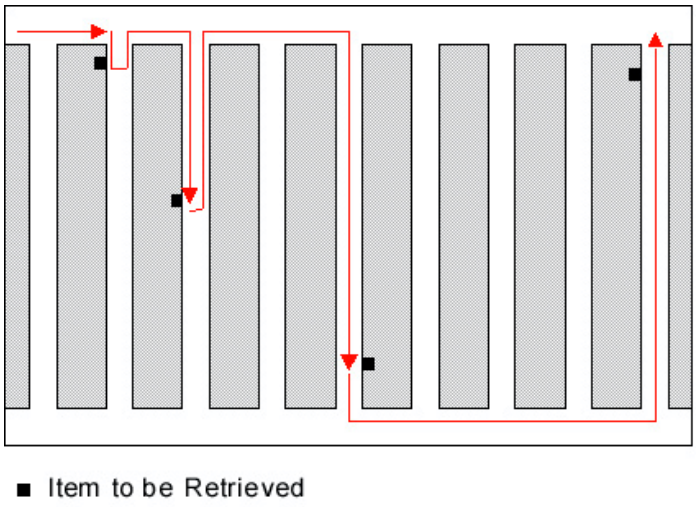

Figure 3.4: Illustration of Travel Assumed in the "Optimal" Strategy.

pick.

3.5.4 Conclusion

We use the traversal strategy in all expected distance calculations in this paper for a variety of reasons.

- The traversal strategy provides accurate travel times when there are a large number of picks per aisle [17] (as is the case in our analyses).
- Calculations for expected distance are very straightforward using the traversal strategy.
- The traversal strategy provides an excellent basis for comparing different design alternatives.

3.6 Aisle Structure

We organize items based on the aisle structure used by Caron *et al.* [5]. This aisle structure has two columns of aisles running horizontally (i.e., parallel with the front end of the ware-

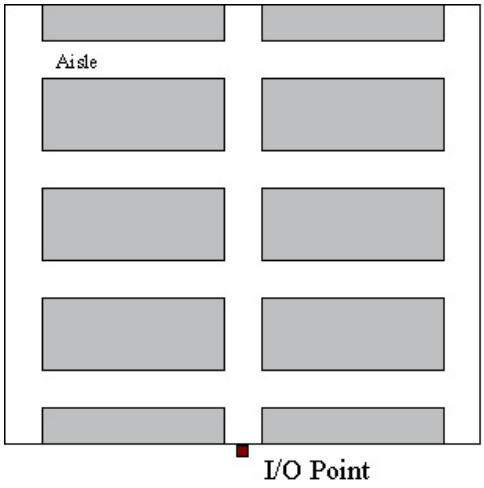

Figure 3.5: Example of the Horizontal Aisle Structure.

house; where the I/O point is located). Figure 3.5 gives an example of a warehouse with a horizontal aisle structure.

The other aisle structure considered was a vertical aisle structure used by Hall [17]. The vertical aisle structure has aisles running perpendicular to the front end of the warehouse. Figure 3.6 gives an example of a warehouse with a vertical aisle structure. This aisle structure is not modeled since it results in longer travel times than the horizontal aisle structure in most cases [5].

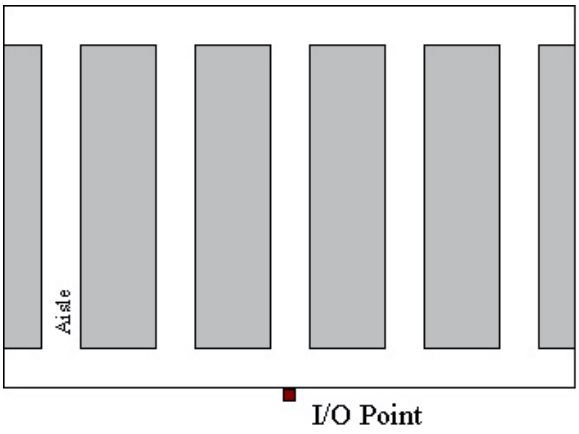

Figure 3.6: Example of the Vertical Aisle Structure.

Since we use a fixed aisle structure in developing layouts, partial aisles will not be used. We

have also assumed that our cost of floorspace area (C_z^a) is a given cost per square ft. This simplifying assumption may have an impact on our analysis. In practice, there may be no cost to utilize existing facilities, but a cost of expansion for any additional floorspace that is required. This will affect forward and reserve analyses, as the size of one department may force the other department to expand outside of existing facilities. We have assumed the forward and reserve department analyses to be independent for our study.

3.7 Problem Summary

Using the cost model developed in Section 3.2, we compare the design options for each department. In our cost model we consider the cost of floorspace and the cost of the labor to retrieve the items in each department. Chapter 4 develops our models to estimate floorspace and retrieval costs in the reserve department while Chapter 5 develops the same for the forward department.

Chapter 4

Reserve Department

Our goal in designing the reserve department is to minimize the cost of the warehouse. This requires us to maximize space utilization, while minimizing material handling within the warehouse. Since the layout that maximizes space utilization is different from one that minimizes material handling, an evaluation of the tradeoff between space utilization and material handling distance is required.

4.1 Notation

The following notation is used throughout our study. The index for departments is z. We denote the reserve department as r when necessary in our notation.

Parameters

I_z^{it} = inventory level of item i (for $i = 1, ..., P$) during period t in department z

N_z = number of picks in a tour for department z (picks/tour)

l_I = length of stocking aisles (ft)

w_E = width of cross aisles (ft)

w_I = width of stocking aisles (ft)

a = number of stocking aisles

NA = set of items that are NVA

VA = set of items that are VA

$HY = NA \bigcap VA$ = set of items located in the hybrid area

$IT = NA \bigcup VA$ = set of all the items in the warehouse

$N\overline{H} = NA - HY$ = set of NVA items not in the hybrid area

$V\overline{H} = VA - HY$ = set of VA items not in the hybrid area

Λ_z^i = demand for item i (for $i = 1, ..., P$) in department z (cases/year)

d^{lat} = average lateral distance to retrieve an item (ft)

d^{long} = average longitudinal distance to retrieve an item (ft)

Variables

$F(x)$ = COI-based ABC curve

A_z^L = floorspace area for layout L in department z (ft^2)

S_z^L = maximum space requirement for layout L in department z (cases)

D_z = expected tour length for department z (ft)

Δ^H = incremental change in distance that occurs when hybrid SKU H is moved to the NVA/VA areas (ft)

Throughout this chapter, as we develop our models for floorspace area and retrieval distances, we illustrate the models with an example. We first present the parameters for the example and later illustrate how the variables are used in our models.

4.1.1 Example Problem Data

The warehouse in the example problem has both forward and reserve departments. We assume that aisles run parallel to the front of the warehouse as illustrated in Figure 3.5, and aisle width is negligible for the reserve department. Items are received and stored in cases

Table 4.1: 8-Week Inventory Summary for the Reserve Department (I_r^{it}).

SKU	Replen. Level	Reorder Point	Inventory Level per Period							
			Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	90	20	40	65	20	40	20	50	10	40
2	170	20	30	50	120	120	90	90	70	100
3	85	40	85	20	40	40	60	20	60	70
4	90	20	70	90	60	20	70	70	90	30
5	120	20	60	40	120	80	70	120	10	120
6	50	20	20	40	40	50	30	30	30	40
7	40	10	30	40	20	20	40	40	10	10
8	200	40	130	80	80	100	40	150	20	50
9	150	20	10	150	30	20	150	50	30	50
10	70	10	20	70	10	30	70	30	30	10
11	50	10	20	40	10	20	10	40	10	40
12	110	20	60	60	10	50	40	110	30	10

that are 3' x 3' x 3' in dimension (including clearances). Aisles are 3' wide to account for operator travel. Cases can be stored 10 high in each storage location.

In our example problem, twelve SKUs ($IT = \{1\text{–}12\}$) are stored in our DC. Four SKUs are specific to NVA orders ($N\overline{H} = \{5\text{–}8\}$), four are specific to VA orders ($V\overline{H} = \{9\text{–}12\}$), and four are common to both VA and NVA orders ($HY = \{1\text{–}4\}$). Thus, the set of items located in the NVA area ($NA = \{1\text{–NA}, 2\text{–NA}, 3\text{–NA}, 4\text{–NA}, 5\text{–}8\}$) and VA area ($VA = \{1\text{–VA}, 2\text{–VA}, 3\text{–VA}, 4\text{–VA}, 9\text{–}12\}$) can be determined. We have 8-week inventory values for all twelve SKUs, which is considered a representative sample. Inventory summaries for the reserve department are presented in Table 4.1.

4.2 Reserve Storage Department

The first value to determine for this problem is the reserve department space requirement. Malmborg [20] relates space requirements to the maximum inventory level for a given set of products over a period of time. The space requirement for an area can be defined as

$$S = \max_t \sum_{i=1}^{P} I^{it}, \tag{4.1}$$

where P items are stored in the warehouse.

The warehouse area must then be related to this space requirement. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

In this analysis we examine three potential layout options:

- **Single Combined Reserve Department** — all SKUs are stored randomly in a single reserve department regardless of product type. This solution should provide the most efficient use of space, but have the largest travel distances.

- **Two Separate Reserve Departments** — NVA and VA SKUs are split into two separate reserve departments. Cases are stored randomly within the departments. This solution should provide the shortest travel distances, but utilize space the least efficiently.

  With two separate reserve departments it will be necessary to store SKUs common to both NVA and VA orders (HY) in each of our reserve departments. For example, if we have 10 units of a SKU in our combined reserve department potential solution, we require more than 10 units combined in the NVA and VA reserve departments for this potential solution. This accounts for the fact that items from a common reserve department can be used to fulfill both NVA and VA orders, while NVA and VA orders must be fulfilled from their own respective reserve departments when the reserve department is separated.

- **Hybrid Reserve Department** — VA and NVA SKUs have separate reserve departments, while SKUs common to both the VA and NVA orders are stored in a hybrid reserve department. In some cases, SKUs common to both the VA and NVA orders may be stored in the NVA and VA areas if their turnover requires them to be close to that particular area's I/O point. Cases are stored randomly within each of the departments. This solution, if configured correctly, should provide both low travel times and efficient use of floorspace.

These three solutions were illustrated earlier in Figure 1.4. We now present our area models for each of the three solutions outlined above.

4.2.1 Combined Reserve Department

Our equation to find the maximum space requirement over the time period of interest for the combined reserve department, layout option 1, is as follows:

$$S_r^1 = \max_t \sum_{i \in IT} I_r^{it}, \tag{4.2}$$

where IT is the set of all items stored in the warehouse.

The value for S_r^1 from (4.2) can then be used to develop a floor plan using the horizontal aisle structure. The dimension from our floor plan gives us the warehouse area for the combined reserve department.

Combined Reserve Department — Example Problem

For our sample problem, we can calculate S_r^1 using historical inventory levels over a given period of time. Twelve SKUs are stored in the DC. Four SKUs are specific to NVA orders ($N\overline{H} = \{5\text{–}8\}$), four are specific to VA orders ($V\overline{H} = \{9\text{–}12\}$), and four are common to both VA and NVA orders ($HY = \{1\text{–}4\}$). We have 8-week inventory values for all twelve SKUs. An inventory summary for the combined reserve department is presented in Table 4.2. The maximum inventory level for the combined reserve department over the 8-week period is 800 cases (the value for week 6).

This value ($S_r^1 = 800$ cases) must then be translated into a floorspace diagram. Since cases of product can be stored 10 high in each storage location we need to allocate floorspace to account for at least 80 cases on the floor. Cases of product in the reserve department are 3' x 3' x 3' in dimension (including clearances). Aisles are 3' wide to account for operator

Table 4.2: 8-Week Inventory Summary for the Combined Reserve Department (I_r^{it}).

SKU	Replen. Level	Reorder Point	Inventory Level per Period							
			Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	90	20	40	65	20	40	20	50	10	40
2	170	20	30	50	120	120	90	90	70	100
3	85	40	85	20	40	40	60	20	60	70
4	90	20	70	90	60	20	70	70	90	30
5	120	20	60	40	120	80	70	120	10	120
6	50	20	20	40	40	50	30	30	30	40
7	40	10	30	40	20	20	40	40	10	10
8	200	40	130	80	80	100	40	150	20	50
9	150	20	10	150	30	20	150	50	30	50
10	70	10	20	70	10	30	70	30	30	10
11	50	10	20	40	10	20	10	40	10	40
12	110	20	60	60	10	50	40	110	30	10
		SUM	575	745	560	590	690	**800**	400	570

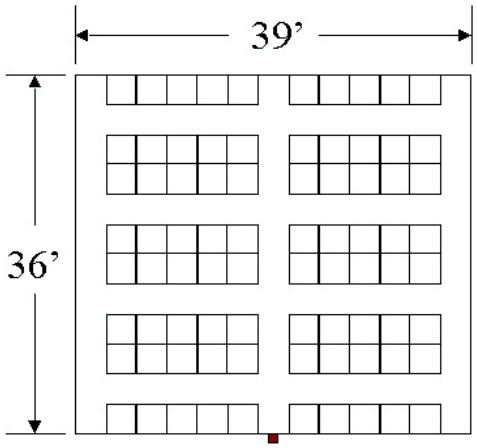

Figure 4.1: Floorplan for the Combined Reserve Department.

travel. Based on these values, and the constraint that aisles in the same column must be the same length and width, the floorplan illustrated in Figure 4.1 has been developed.

4.2.2 Two Separate Reserve Departments

Our equation to find the maximum space requirement over the time period of interest for the two separate reserve departments, layout option 2, is as follows:

$$S_r^2 = \max_t \sum_{i \in NA} I_r^{it} + \max_t \sum_{i \in VA} I_r^{it}, \tag{4.3}$$

Table 4.3: 8-Week Inventory Summary for NVA SKUs (I_r^{it}).

SKU	Replen. Level	Reorder Point	Inventory Level per Period							
			Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1-NA	80	10	20	20	70	60	10	80	10	20
2-NA	120	10	110	40	40	100	70	80	40	40
3-NA	60	20	30	10	40	30	30	0	60	30
4-NA	70	10	50	30	60	20	40	70	60	20
5	120	20	60	40	120	80	70	120	10	120
6	50	20	20	40	40	50	30	30	30	40
7	40	10	30	40	20	20	40	40	10	10
8	200	40	200	80	80	150	40	150	20	50
		SUM	520	300	470	510	330	**570**	240	330

where NA is the set of items in the NVA area, and VA is the set of items in the VA area. Inventory levels for the hybrid items need to be adjusted from the combined reserve department problem values since they are located in both NA and VA. Although we do not present any additional notation for this adjustment, our example that follows illustrates the concept by increasing the quantity of hybrid items in both areas.

The warehouse area must then be related to S_r^2. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

Two Separate Reserve Departments — Example Problem

To find the space requirement for the layout with two separate reserve departments we must find the maximum inventory level for both individual areas. The maximum inventory levels for the NVA items over the 8-week period is presented in Table 4.3. The maximum inventory levels for the VA items over the 8-week period is presented in Table 4.4. It should be noted that SKUs 1–4 appear in both Table 4.3 and Table 4.4 since the two areas are independent from one another. The replenishment level for SKUs 1–4 can be different for this reason as well.

The space requirement for two separate reserve departments is the maximum inventory for the NVA items over the 8-week period (the value for week 6) and the maximum inventory

Table 4.4: 8-Week Inventory Summary for VA SKUs (I_r^{it}).

SKU	Replen. Level	Reorder Point	Inventory Level per Period							
			Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1-VA	70	10	20	10	0	20	70	0	0	20
2-VA	99	10	30	0	80	20	0	10	60	90
3-VA	60	20	60	10	30	50	60	20	20	60
4-VA	60	10	60	30	60	20	60	60	60	20
9	150	20	10	110	30	20	150	50	30	50
10	70	10	20	60	10	30	40	30	30	10
11	50	10	20	40	10	20	10	40	10	40
12	110	20	60	30	10	50	40	110	30	10
		SUM	280	290	230	230	**430**	320	240	300

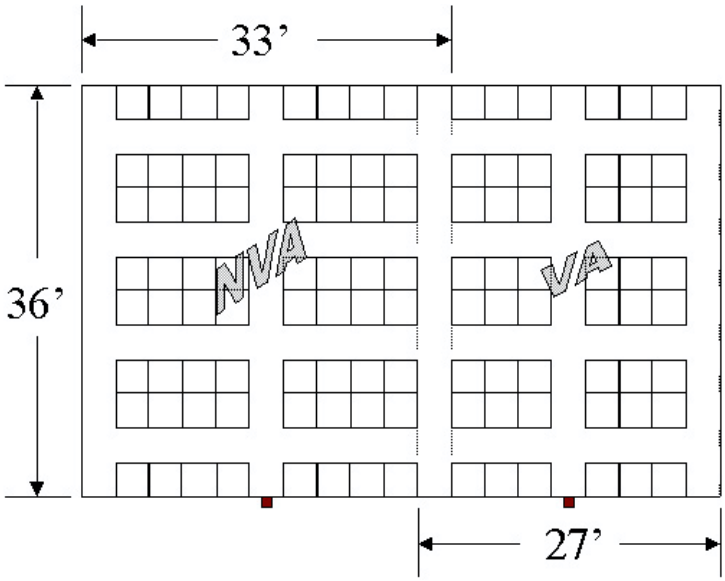

Figure 4.2: Floorplan for Two Separate Reserve Departments.

for the VA items over the 8-week period (the value for week 5). This gives us a maximum inventory level of 1000 cases for a layout with separate reserve departments.

This value ($S_r^2 = 1000$ cases) must then be translated into a floorplan. Since cases of product can be stored 10 high in each storage location we need to allocate floorspace to account for a minimum of 100 cases on the floor. Cases of product in the reserve department are 3' x 3' x 3' in dimension (including clearances). Aisles are 3' wide to account for operator travel. Based on these values, and the constraint that aisles in the same column must be the same length and width, the floorplan illustrated in Figure 4.2 has been developed.

4.2.3 Hybrid Reserve Department

The premise behind having a layout with a hybrid area is to minimize the negative effects of storing items common to both NVA and VA orders in a single area, while reaping the benefits of locating items closer to the point at which they are used. Our reserve department in this case would require space for the maximum inventory level of items unique to NVA and VA SKUs (items in $N\overline{H}$ and $V\overline{H}$), and some quantity of the hybrid SKUs (HY) that are common to both NVA and VA.

The question of how many items for SKUs in HY to account for remains a difficult one. Our combined reserve department (layout option 1) represents the least amount of floorspace required, since it has been designed to maximize space utilization. Our two separate reserve departments (layout option 2) represents the most amount of floorspace required, since it has been designed to minimize travel distance. For this reason the value of our total inventory for our hybrid layout falls somewhere between the values for our combined layout and our separate layout.

We create an initial hybrid layout that places all the hybrid SKUs (HY) in an area separate from the NVA and VA SKUs. Our equation to find the maximum space requirement over the time period of interest for the initial hybrid layout, layout option 3, is as follows:

$$S_r^3 = \max_t \sum_{i \in N\overline{H}} I_r^{it} + \max_t \sum_{i \in V\overline{H}} I_r^{it} + \max_t \sum_{i \in HY} I_r^{it}, \tag{4.4}$$

The warehouse area for the hybrid layout must then be related to S_r^3. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

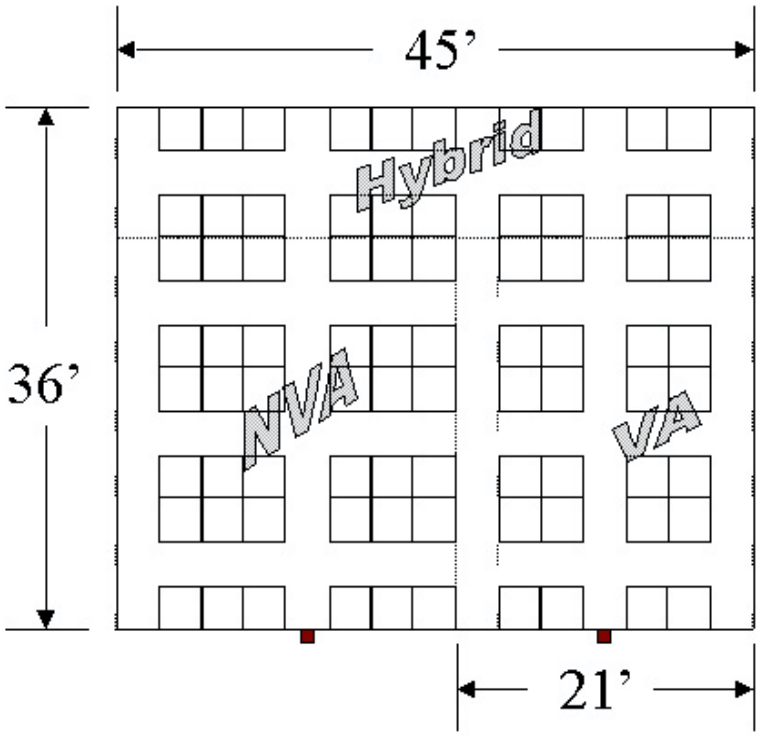

Figure 4.3: Floorplan of the Initial Hybrid Layout.

Hybrid Reserve Department — Example Problem

The maximum inventory level for NVA SKUs ($N\overline{H}$) is 340 cases. The maximum inventory level for VA SKUs ($V\overline{H}$) is 240 cases. The maximum inventory level for Hybrid SKUs (HY) is 240 cases. This requires us to allocate space for 820 total cases for the hybrid layout.

This value ($S_r^3 = 820$ cases) must then be translated into a floorplan. Since cases of product can be stored 10 high in each storage location we need to allocate floorspace to account for at least 82 cases on the floor. Based on the assumption that aisles in the same column must be the same length and width, the floorplan illustrated in Figure 4.3 has been developed.

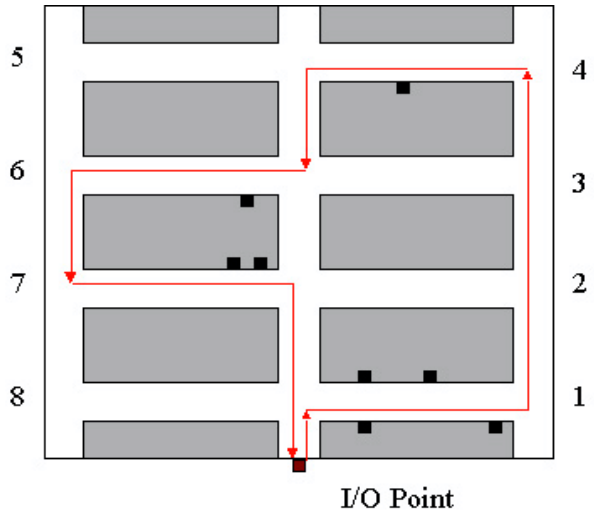

Figure 4.4: Illustration of Travel Assumed in Caron's Algorithm.

4.3 Reserve Department Retrieval

In this section we examine an algorithm for calculating the expected distance for a tour in a warehouse. This algorithm was presented by Caron *et al.* [5].

4.3.1 Reserve Department — Caron's Algorithm

Caron's algorithm assumes that the picker moves only along the aisle floor and follows a traversal strategy. Figure 4.4 illustrates how the traversal strategy would route a picker through a series of points in a warehouse. The aisles are organized into two columns of aisles in Figure 4.4. Column A contains aisles $1-4$, and column B contains aisles $5-8$. The picker travels the entire length of any aisle containing at least one pick. Aisles are served from front to back down one column of aisles and then back to front down the other column of aisles. It is important to note that Caron's algorithm assumes negligible aisle width, so items from both sides of an aisle can be retrieved from the centerline of the aisle. This is illustrated in aisle 1 of Figure 4.4.

In Figure 4.4 an even number of aisles on either side of the I/O point are visited. When

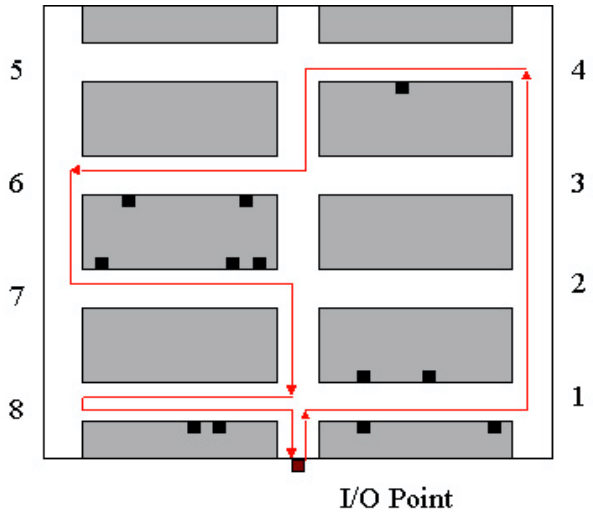

Figure 4.5: Illustration of Travel with Complete Return Trip.

an odd number of aisles are visited an extra trip is required to get back to the I/O point. Figure 4.5 illustrates how an operator must be routed to completely traverse every aisle. An operator travels the length of every aisle on the left side of the warehouse, and performs an additional trip in aisle 8 to return to the I/O point. Since this is clearly wasted travel, a modification to the traversal strategy is used.

Caron's algorithm does not apply the traversal strategy when an odd number of aisles are visited. Caron *et al.* [5] asserts that when and odd number of aisles are visited a routing policy with an even number of completely traversed aisles and return travel in the aisle with the largest gap should be employed. Figure 4.6 illustrates how an operator would be routed in the same situation under Caron's algorithm. Caron *et al.* [5] presents the following analytical function that describes the COI-based ABC curve:

$$F(x) = \frac{(1+s)\cdot x}{s+x}, \tag{4.5}$$

where x indicates the ratio of required storage space to total storage space, and s is the ABC shape factor. $F(x)$ represents the fraction of total warehouse activity associated with x. Table 4.5 presents shape factors for various ABC curves. Since random storage is assumed

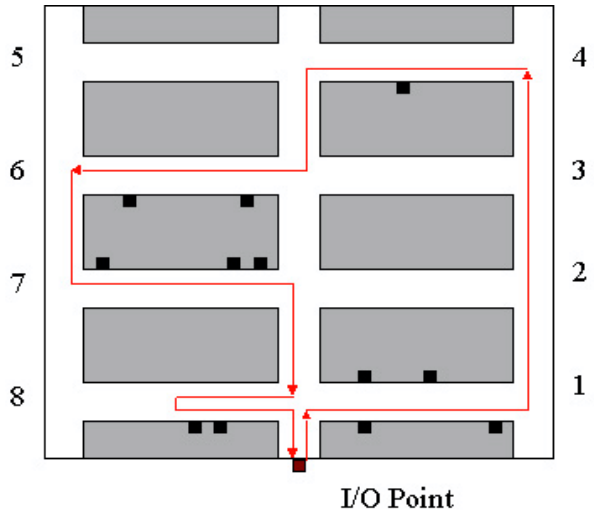

Figure 4.6: Illustration of Travel Assumed in Caron's Algorithm when an Odd Number of Aisles are Visited.

Table 4.5: Values of s for Different ABC Curves.

ABC Curve	s value
50/50	∞
60/40	0.8000
70/30	0.2250
80/20	0.0700
90/10	0.0125

for the reserve department, a 50/50 ABC curve ($s = \infty$) is used. In our example 99,999 is used to approximate ∞.

Caron's algorithm breaks tours into longitudinal and lateral distance. An equation for expected travel for the reserve department is as follows [5]:

$$E[D_r] = E[D_r^{lat}] + E[D_r^{long}]. \tag{4.6}$$

An approximation for the expected longitudinal distance (between aisle travel) is [5]:

$$E[D_r^{long}] = 2 \cdot \sum_{j=2}^{a/2} \left(w_I \cdot (j-1) \left\{ \left[F\left(\frac{2 \cdot j}{a}\right) \right]^N - \left[F\left(\frac{2 \cdot j - 2}{a}\right) \right]^N \right\} \right). \tag{4.7}$$

An approximation for the expected lateral distance (within aisle travel) is as follows [5]:

$$E[D_r^{lat}] = (l + w_E) \cdot \sum_{i=1}^{a} \left(1 - \left\{ 1 - \left[F\left(\frac{i}{a}\right) - F\left(\frac{i-1}{a}\right) \right] \right\}^N \right). \tag{4.8}$$

4.3.2 Reserve Department — Example

The algorithm presented has been used to evaluate the data for our example problem. I/O points have been assumed to be located at the bottom center of each area analyzed.

Table 4.6 illustrates the values used in Caron's algorithm calculation for the combined reserve department layout. The combined reserve department has a total expected travel distance of 197.97 ft.

Table 4.6: Input to Caron's Algorithm for the Combined Reserve Department (ft).

aisles (a)	N	l_I	w_I	w_E	s
8	20	15	9	3	99999

Table 4.7 presents the values used in the calculation for the separate reserve department layout. The separate reserve department has a total expected travel distance of 165.59 ft.

Table 4.7: Input to Caron's Algorithm for the Separate Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	8	20	12	9	3	99999
VA	8	20	9	9	3	99999

Our hybrid layouts for our NVA and VA areas violate the rectangular layout assumed by Caron *et al.* [5]. These layouts are presented in Figure 4.7. Because of this violation, aisles must be moved to extend the pair of columns of aisles for our calculation. Aisles are moved so they minimize the number of additional aisles created, while providing at least as much storage space as our initial hybrid layout. This is illustrated in Figure 4.8.

This method of extending columns assumes uniform demand levels between HY and NVA/VA

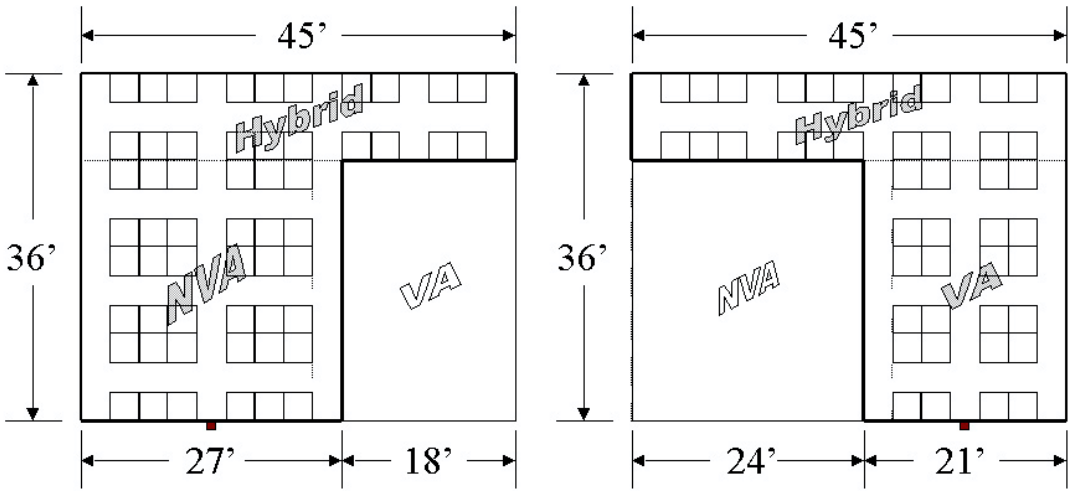

Figure 4.7: NVA and VA Configurations for the Initial Hybrid Layout.

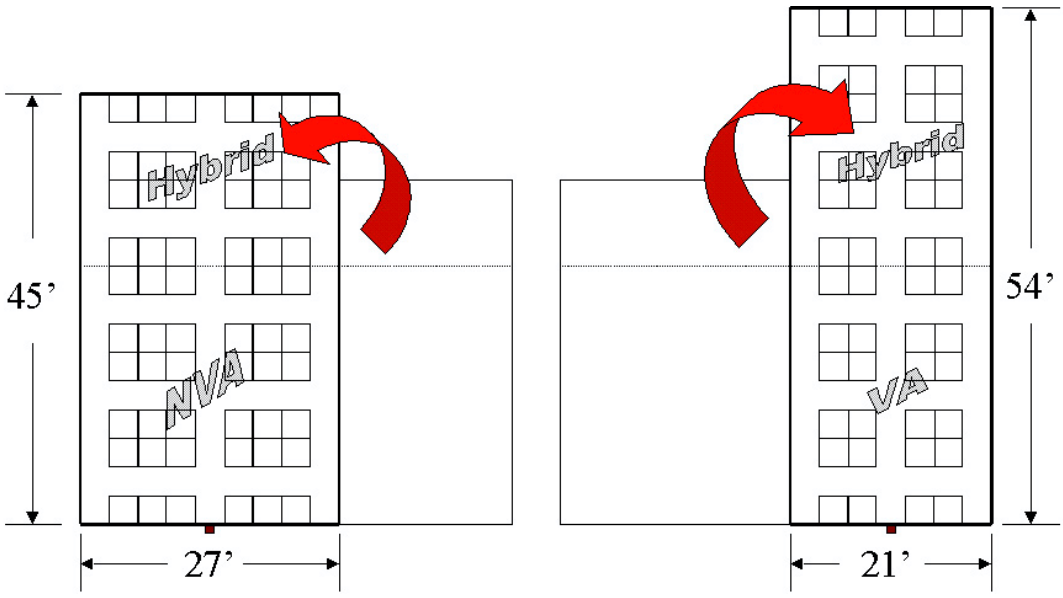

Figure 4.8: Configurations for the Initial Hybrid Layout with Extended Aisle Structures.

areas of the reserve department. It should be noted that if there is a large discrepancy between HY demand and NVA/VA demand, extending our columns of aisles does not provide an accurate solution.

Table 4.8 illustrates the values used in the calculation for the initial hybrid reserve department layout. The initial hybrid reserve department has a total expected travel distance of 187.82 ft. Table 4.9 presents a summary of the results of the calculation for the reserve department.

Table 4.8: Input to Caron's Algorithm for the Initial Hybrid Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	10	20	9	9	3	99999
VA	12	20	6	9	3	99999

Table 4.9: Results of Calculations using Caron's Algorithm for the Reserve Department (ft).

		Distance/Tour	**Percent of Demand**	**Total Dist/Tour**	**Area**
Combined	All	197.97	100%	197.97	1404
Separate	NVA	175.63	55%	165.59	2160
	VA	153.30	45%		
All in Hybrid	NVA	187.20	55%	187.82	1620
	VA	188.57	45%		

4.4 Hybrid Tradeoff Analysis

The three layouts we have developed thus far are the combined, separate and initial hybrid. The combined layout minimizes warehouse space, but has high order retrieval times. The separate layout divides the reserve department into VA and NVA departments. This reduces putaway and replenishment costs due to shorter retrieval times, but requires more overall space.

The initial hybrid layout places all of the hybrid items in a separate department that is easily accessible to the VA and NVA areas. This layout assumes that all hybrid items should be stored in the hybrid area. However, if a SKU has a high turnover, it should be moved from

the hybrid area to the NVA/VA areas of the warehouse, where it would be closer on average to the I/O point and reduce travel distance.

The following methodology has been developed to determine if these hybrid items should be stored in the NVA/VA areas of the warehouse or left in the hybrid area.

1. **Hybrid SKUs are ranked in order of turnover ratio.**

2. **The HY SKU with the highest turnover ratio is selected and added to the NVA/VA areas of the department** – The SKU with the largest turnover ratio has the largest demand to inventory ratio. Hence, a SKU with a high turnover ratio will experience a large decrease in retrieval time when it is moved to the NVA/VA departments. We refer to the selected SKU as H.

3. **Calculate reserve department area based on the space requirement (S_r^4) for the hybrid layout** – The equation for reserve department area is as follows:

$$S_r^4 = \max_t \sum_{i \in N\overline{H}+H} I_r^{it} + \max_t \sum_{i \in V\overline{H}+H} I_r^{it} + \max_t \sum_{i \in HY-H} I_r^{it}. \tag{4.9}$$

   The warehouse area for the hybrid layout must then be related to S_r^4. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

4. **Calculate the incremental change in tour length based on moving the selected hybrid SKU to the NVA/VA areas** – Due to the nature of Caron's algorithm, it is not feasible to calculate the tour length for the hybrid tradeoff analysis. However, an approximate tour length change can be determined by calculating the incremental change in tour length and modifying our results from our initial hybrid layout. The incremental change in distance from moving an item from the hybrid area to the non-hybrid areas can be represented with the following equation for the NVA area,

$$\Delta_{NVA}^{H} = \left[d_{HY}^{long} + d_{HY}^{lat}\right] - \left[d_{NVA}^{long} + d_{NVA}^{lat}\right], \tag{4.10}$$

and for the VA area,

$$\Delta_{VA}^{H} = \left[d_{HY}^{long} + d_{HY}^{lat}\right] - \left[d_{VA}^{long} + d_{VA}^{lat}\right]. \tag{4.11}$$

We then must modify our expected distance to account for the effect of moving our hybrid SKU to the NVA/VA areas of the reserve department. This is approximated with the following equation for the NVA area,

$$E[D_r^{N\overline{H}+H}] = E[D_r^{N\overline{H}}] - \left[\frac{\sum\limits_{i\in H}\Lambda_r^i}{\sum\limits_{i\in IT}\Lambda_r^i}\right]\Delta_{NVA}^{H}, \tag{4.12}$$

and for the VA area,

$$E[D_r^{V\overline{H}+H}] = E[D_r^{V\overline{H}}] - \left[\frac{\sum\limits_{i\in H}\Lambda_r^i}{\sum\limits_{i\in IT}\Lambda_r^i}\right]\Delta_{VA}^{H}. \tag{4.13}$$

5. **Calculate cost** – Total cost can be calculated using (3.1).

6. **Update inventory and area values** – set $N\overline{H} = N\overline{H} + H$; $V\overline{H} = V\overline{H} + H$; and $HY = HY - H$. $E[D_r^{N\overline{H}}]$, $E[D_r^{V\overline{H}}]$, and reserve department area (A_r) should be set to the updated value.

7. **Continue until all hybrid SKUs are examined** – Due to the discrete nature of our department layout, fluctuations in area require us to evaluate every hybrid SKU. Note that there may be instances where step 7 can be shortened, but in general, there is no way to adequately predict how many SKUs to consider beforehand. The hybrid tradeoff layout with the lowest total cost should be selected.

4.4.1 Hybrid Tradeoff Analysis Example

A hybrid tradeoff analysis has been performed for the sample problem. We have obtained the following cost and requirement data for the sample problem:

- 1,400,000 picks/year are expected for the facility
- 20 picks/tour (on average)
- operators are paid $35,000/year
- a warehouse cost of $5/ft^2 has been estimated
- the average operator works 1680 hours/year (35 hours/week $\times$ 48 weeks/year)
- walking speed is 4 ft/sec (2.7 mph)

Table 4.10 presents the SKUs for the sample problem ranked in order of turnover.

Table 4.10: SKUs Ranked by Turnover.

SKU		**Avg. Inv (Cases)**	**Demand**	**Turnover**
2	HY	83.8	479.0	5.72
8	NVA	81.3	109.2	1.34
11	VA	23.8	25.4	1.07
7	NVA	26.3	27.1	1.03
5	NVA	77.5	75.1	0.97
1	HY	35.6	34.4	0.97
4	HY	62.5	59.0	0.94
6	NVA	35.0	31.5	0.90
3	HY	49.4	42.8	0.87
10	VA	33.8	29.1	0.86
12	VA	46.3	38.1	0.82
9	VA	61.3	49.4	0.81

The *HY* SKU with the highest turnover is added to the NVA/VA areas of the department. Based on the data presented in Table 4.10, SKU 2 has the highest turnover (5.72) of the four SKUs currently located in the hybrid area. Moving SKU 2 from the hybrid department

to the NVA/VA departments saves us 9.79 ft/tour and 13.58 ft/tour in the NVA and VA departments respectively. Based on the demand for SKU 2, this change in location results in a total distance/tour of 176.32 ft. Based on (3.2), we need 0.51 operators to staff this layout[1]. Our total area for the reserve department when SKU 2 is moved to the NVA/VA areas of the department is 1836 ft^2. When inserted into (3.1), these values for L_r (0.51 operators/year) and A_r (1836 ft^2) yield a total cost of $\$27,037$/year for our warehouse. This is an improvement over our layout with all hybrid items stored in the hybrid department ($\$27,121$).

SKU 1 has the next highest turnover (0.97) of the three SKUs remaining in the hybrid area. Moving SKU 1 from the hybrid department to the NVA/VA departments saves us 0.70 ft/tour and 0.97 ft/tour in the NVA and VA departments respectively. Based on the demand for SKU 1, this change in location results in a total distance/tour of 175.50 ft. Our total area for the reserve department when SKU 1 is moved to the NVA/VA areas of the department is 1863 ft^2. Based on the cost and demand data obtained, the total cost of our warehouse is $\$27,088$, which is more expensive than our layout with just SKU 2 located in the NVA/VA areas ($\$27,037$).

SKU 4 has the highest turnover (0.94) of the two SKUs remaining in the hybrid area. Moving SKU 4 from the hybrid department to the NVA/VA departments saves us 1.22 ft/tour and 1.69 ft/tour in the NVA and VA departments respectively. Based on the demand for SKU 4, this change in location results in a total distance/tour of 174.06 ft. Our total area for the reserve department when SKU 4 is moved to the NVA/VA areas of the department is 2025 ft^2. Based on the cost and demand data obtained, the total cost of our warehouse is $\$27,757$, which is more expensive than our layout with just SKU 2 located in the NVA/VA areas ($\$27,037$).

[1]We have assumed operators can be hired on an hourly basis, so fractional operators are allowed. Were this not the case, we would need to hire a single operator ($L_r = 1$).

Moving SKU 3 to the non-hybrid areas of our reserve department would result in a hybrid layout with no hybrid area (i.e., a separate layout). Therefore, SKU 4 is the final SKU we need to analyze. However, to test the accuracy of this method of tradeoff analysis we calculated an expected distance of 173.02 ft for our hybrid tradeoff with all 4 SKUs moved to non-hybrid areas. This is 7.43 ft higher than our separate value calculated using Caron's algorithm (165.59 ft). Our layout with just SKU 2 located in the NVA/VA areas ($\$27,037$) is the least expensive hybrid layout option.

Tables 4.11 and 4.12 present the distance calculations for our hybrid tradeoff. Table 4.11 presents the calculations for the estimated savings per tour based on between aisle (BA) and within aisle (WA) travel distance. Table 4.12 applies our results from Table 4.11 to obtain the total distance per tour. It should be noted that our values for BA and WA distance in Table 4.11 do not change for our hybrid tradeoff. This is due to the fact that we assume our layout stays the same when calculating average distance for the hybrid tradeoff. In reality our distances would change slightly when aisles are added/removed from the layout. We see this change in distance as being relatively small when compared with the amount of calculations required for a tradeoff with a large number of SKUs.

Table 4.11: Calculation of the Savings/Tour for the Hybrid Tradeoff Layouts (ft).

SKU Added to		**New Avg Dist.**		**Old Avg Dist.**		**Incr. Savings**		
NVA/VA		BA	WA	BA	WA	Savings/Visit	% of Demand	Savings/Tour
SKU 2	NVA	13.5	7.5	31.5	12.0	22.5	43.5%	9.79
	VA	13.5	4.5	31.5	12.0	25.5	53.3%	13.58
SKU 1	NVA	13.5	7.5	31.5	12.0	22.5	3.1%	0.70
	VA	13.5	4.5	31.5	12.0	25.5	3.8%	0.98
SKU 4	NVA	13.5	7.5	31.5	12.0	22.5	5.4%	1.22
	VA	13.5	4.5	31.5	12.0	25.5	6.6%	1.69

Table 4.13 presents the results of the hybrid tradeoff analysis. Table 4.13 applies cost for our reserve department to our distance and area results to give us values for total cost for our layouts.

Table 4.12: Calculation of the Total Distance/Tour for the Hybrid Tradeoff Layouts (ft).

SKU Added to NVA/VA		Savings/Tour	Distance/Tour	% of Demand	Total Dist/Tour
SKU 2	NVA	9.79	177.41	55%	176.32
	VA	13.58	174.99	45%	
SKU 1	NVA	0.70	176.71	55%	175.50
	VA	0.98	174.01	45%	
SKU 4	NVA	1.22	175.49	55%	174.06
	VA	1.69	172.32	45%	

Table 4.13: Results of the Hybrid Tradeoff Analysis (ft).

	Total Dist/ Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost
All in Hybrid	187.82	76.67	1620	$19,021	$8,100	$27,121
SKU 2 added	176.32	81.67	1836	$17,857	$9,180	$27,037
SKUs 1 & 2 added	175.50	82.05	1863	$17,773	$9,315	$27,088
SKUs 1, 2, & 4 added	174.06	82.71	2025	$17,632	$10,125	$27,757

4.5 Reserve Department — Comparison of Results

Table 4.14 presents a summary of the area required for each of our alternatives. As was expected, the combined layout required the least area, while the separate layout required the most area.

Table 4.14: Comparison of the Area Required for the Reserve Layouts.

	Area (ft^2)
Combined	1404
Initial Hybrid	1620
SKU 2 added to NVA/VA	1836
Separate	2160

Results from the distance calculations performed on the test data are presented in Table 4.15. The separate layout had the shortest travel distance of all the cases, and the combined layout had the longest travel distance in all cases.

This example provided us with the results that we expected. Namely, the combined reserve department layout provided us with the smallest reserve department, but had the largest travel distances. The two separate reserve department layout provided us with the shortest

Table 4.15: Comparison of Distance Results for the Reserve Department.

	Distance/Tour (ft)	**% of Max**
Separate	165.59	83.6%
SKU2 added to NVA/VA	176.32	89.1%
Initial Hybrid	187.82	94.9%
Combined	197.97	100.0%

travel distances, but had the largest reserve department size. The hybrid layouts provided us with values for both travel distance and reserve department size as expected.

Table 4.16 presents the cost results for the reserve department. Our hybrid layout where SKU 2 has been moved to the NVA/VA areas has the lowest total cost ($\$27,037$). The combined layout has the lowest warehouse area cost ($\$7,020$), but the highest labor cost ($\$20,049$). The separate layout has the lowest labor cost ($\$16,770$), but the highest warehouse area cost ($\$10,800$).

Table 4.16: Cost Results for the Reserve Department.

	Labor Cost	**WH Cost**	**Total Cost**
SKU 2 added	$17,857	$9,180	$27,037
Combined	$20,049	$7,020	$27,069
All in Hybrid	$19,021	$8,100	$27,121
Separate	$16,770	$10,800	$27,570

4.6 Effect of Hybrid Item Location on Travel Time

The algorithm used to calculate expected distance for our reserve hybrid layouts assumes items are uniformly distributed. This is not the case for our hybrid layout, as we often have our high movers in our NVA or VA departments, while items with lower turnover values are stored in the hybrid area. This section examines the effect of hybrid item location on travel time.

Two methods for allocating products in the hybrid layout were examined. These methods are illustrated in Figure 4.9. Hybrid orientation A locates hybrid items on the far side of one

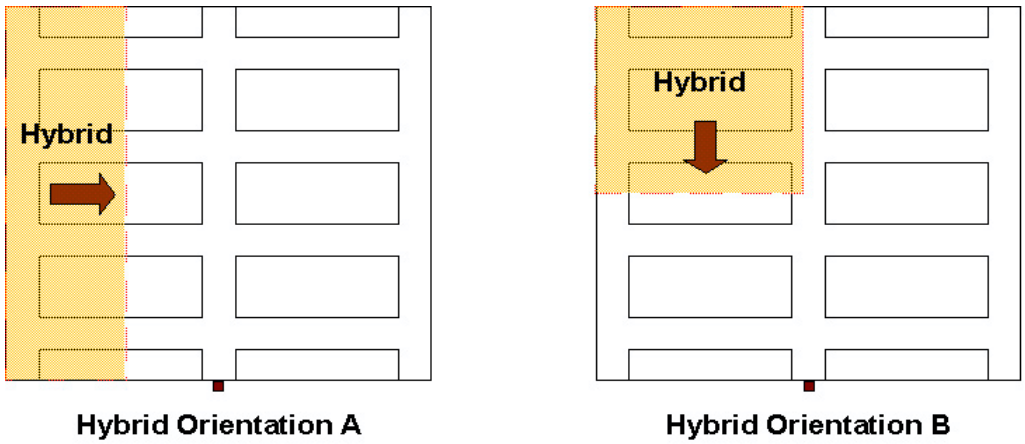

Figure 4.9: Methods for Allocating Items in the Hybrid Area.

of the columns of aisles. An equal number of items are located in each aisle in the column. Hybrid orientation B locates items starting in one of the rows in the back of the warehouse. Hybrid orientation B will completely fill a row before locating items in another row. Items are only located in rows on one side of the central aisle, and rows are filled from the back of the warehouse to the front.

Simulations were performed for the two orientations described above, where 500 SKUs were created following five different ABC curves:

- 50/50
- 60/40
- 70/30
- 80/20
- 90/10

Figure 4.10 presents the layout of the facility used in the hybrid item allocation simulations. Ten aisles are arranged horizontally in two rows of aisles. Aisles are 70' in length and are spaced at 10' intervals. 1000 replications were run for each simulation. The hybrid area

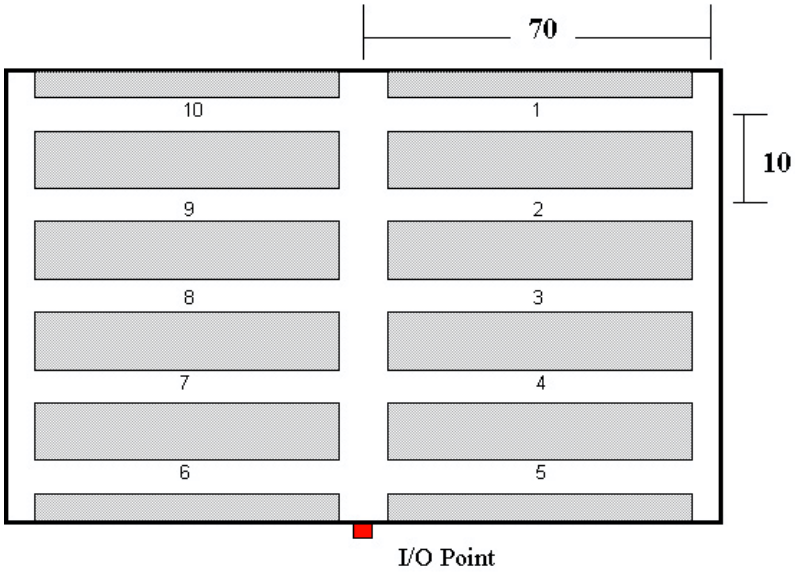

Figure 4.10: Layout of the Facility Used in the Hybrid Item Allocation Simulations.

ranges in size from 10% to 50% of the inventory in the warehouse. It is assumed that all hybrid items have low turnover values. This assumption provides us with the greatest impact on travel time for the analysis. The simulation results are compared with the results with no hybrid area.

Figure 4.11 presents a distance comparison for the two methods of allocating hybrid items in the warehouse. The size and method of allocating items to the hybrid area had little affect on travel distance. The demand curve followed by the inventory had the largest impact on tour distance. An ABC curve with a very skewed demand distribution (i.e., a 90/10 ABC curve) tended to have short travel distances regardless of the allocation of hybrid items, whereas a warehouse with a fairly even distribution of demand (i.e., a 50/50 ABC curve) tended to have longer travel distances. However, it does appear that layout orientation B (fill from the rear) is superior, which is expected under the traversal approach used by the order-pickers. Table 4.17 presents the results of the average distance comparison for 30 items per order.

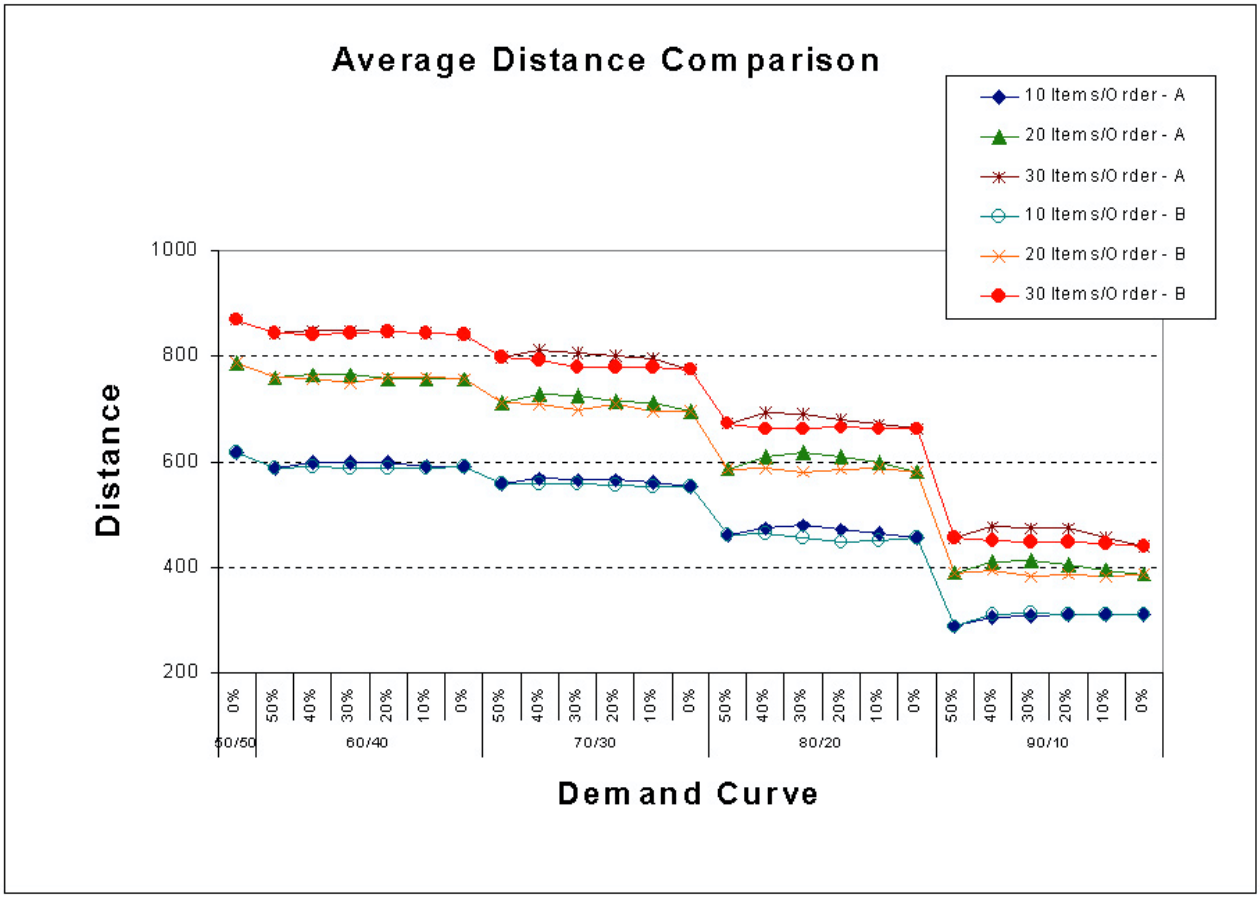

Figure 4.11: Average Distance Comparison when Hybrid Items are Included in a Layout.

Table 4.17: Results of the Average Distance Comparison for 30 Items per Order.

	60/40		**70/30**		**80/20**		**90/10**	
% HY Items	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
50%	843.6	843.6	797.8	797.8	671.4	671.4	455.0	455.0
40%	848.4	839.7	810.1	792.2	693.2	662.1	475.8	448.1
30%	847.6	842.1	806.0	779.8	690.7	660.6	473.3	446.3
20%	845.4	844.3	800.2	780.2	679.7	664.2	471.7	446.3
10%	842.2	843.8	795.3	780.3	670.5	661.4	455.0	444.5
0%	840.8	840.8	775.2	775.2	661.0	661.0	439.9	439.9

Chapter 5

Forward Department

Our goal in designing the forward department is to minimize the cost of the warehouse. This requires us to maximize space utilization, while minimizing material handling within the warehouse. Since the layout that maximizes space utilization is different from one that minimizes material handling, an evaluation of the tradeoff between space utilization and material handling distance is required.

5.1 Notation

The following notation is used throughout our study. The index for departments is z. We denote the forward department as f when necessary in our notation.

Parameters

I_z^{it} = inventory level of item i (for $i = 1, ..., P$) during period t in department z

N_z = number of picks in a tour for department z (picks/tour)

l_I = length of stocking aisles (ft)

w_E = width of cross aisles (ft)

w_I = width of stocking aisles (ft)

a = number of stocking aisles

NA = set of items that are NVA

VA = set of items that are VA

$HY = NA \bigcap VA$ = set of items located in the hybrid area

$IT = NA \bigcup VA$ = set of all the items in the warehouse

$N\overline{H} = NA - HY$ = set of NVA items not in the hybrid area

$V\overline{H} = VA - HY$ = set of VA items not in the hybrid area

Λ_z^i = demand for item i (for $i = 1, ..., P$) in department z (cases/year)

d^{lat} = average lateral distance to retrieve an item (ft)

d^{long} = average longitudinal distance to retrieve an item (ft)

Variables

$F(x)$ = COI-based ABC curve

A_z^L = floorspace area for layout L in department z (ft^2)

S_z^L = maximum space requirement for layout L in department z (cases)

D_z = expected tour length for department z (ft)

Δ^H = incremental change in distance that occurs when hybrid SKU H is moved to the NVA/VA areas (ft)

Throughout this chapter, as we develop our models for floorspace area and retrieval distances, we illustrate the models with an example. We first present the parameters for the example and later illustrate how the variables are used in our models.

5.1.1 Example Problem Data

Aisles run parallel to the front of the warehouse in the forward department (as illustrated in Figure 3.5). Aisle width is negligible for the forward department. Items are received and stored in cases of like size and style.

Table 5.1: Number of Rows Dedicated in the Forward Department for Hybrid SKUs (HY) in the Separate and Combined Hybrid Areas (I_f^{it}).

	Number of Rows		
SKU	**VA**	**NVA**	**HY**
1	2	2	2
2	3	4	5
3	3	3	3
4	2	3	4

Table 5.2: Number of Rows Dedicated in the Forward Department for Non-Hybrid SKUs (I_f^{it}).

SKU	Number of Rows
5	3
6	2
7	2
8	5
9	2
10	2
11	2
12	2

In our example problem, twelve SKUs ($IT = \{1\text{–}12\}$) are stored in our DC. Four SKUs are specific to NVA orders ($N\overline{H} = \{5\text{–}8\}$), four are specific to VA orders ($V\overline{H} = \{9\text{–}12\}$), and four are common to both VA and NVA orders ($HY = \{1\text{–}4\}$). Thus, the set of items located in the NVA area ($NA = \{1\text{–NA}, 2\text{–NA}, 3\text{–NA}, 4\text{–NA}, 5\text{–}8\}$) and VA area ($VA = \{1\text{–VA}, 2\text{–VA}, 3\text{–VA}, 4\text{–VA}, 9\text{–}12\}$) can be determined.

We do not specify inventory levels for the forward department, since rows in the picking racks are dedicated to a particular SKU. Table 5.1 presents the number of rows required in the forward department for hybrid SKUs (HY) for the separate and combined hybrid areas. Table 5.2 presents the number of rows required in the forward department for non-hybrid SKUs. Note that for the forward department, the value of I_f^{it} is typically constant for all values of t.

The warehouse processes 40,000 orders per period in the forward department. Rows are assumed to be 3' x 6' x 6' in dimension (including clearances).

5.2 Forward Storage Department

The forward department is comprised of flow racks that store smaller quantities of cases that are convenient for order pickers when retrieving items. One or more rows are dedicated to a single SKU, as specified with the I_f^{it} values. Since space must be dedicated for each row of inventory in the forward department, we must modify (4.1) to the following:

$$S = \sum_{i=1}^{P} \max_t \{I_f^{it}\}. \tag{5.1}$$

Note that in general, I_f^{it} will typically be constant for all values of t. This gives us the sum of the maximum inventory for each SKU over the given period of time. The warehouse area must then be related to this space requirement. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

Two potential solutions are examined in the forward department:

- **Two Separate Forward Departments** — NVA and VA SKUs are split into two separate forward departments. Each hybrid SKU must be stored independently in each forward department. This solution should provide the shortest travel distances, but has the least efficient use of space.

- **Hybrid Forward Department** — SKUs common to both the VA and NVA orders are stored in a hybrid forward department. VA and NVA SKUs have separate forward departments. This solution should provide both low travel distances and efficient use of floorspace.

These two solutions were illustrated in Figure 1.5. We now present our area models for each of the solutions outlined above.

5.2.1 Two Separate Forward Departments

Our equation to find the maximum space requirement over the 8-week period for the two separate forward departments is as follows:

$$S_f^1 = \sum_{i \in NA} \max_t \{I_f^{it}\} + \sum_{i \in VA} \max_t \{I_f^{it}\}. \tag{5.2}$$

where I_f^{it} is the number of rows required for the appropriate set of SKUs.

The value for S_f^1 from (5.2) can be used to develop a floor plan based on the horizontal aisle structure, that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

To find the space requirement for two separate forward departments we must find the maximum inventory level for both individual areas. Table 5.1 presented the number of rows dedicated for hybrid SKUs (HY) and Table 5.2 presented the number of rows dedicated in the forward department for non-hybrid SKUs.

We see that 24 rows are required for NVA SKUs, and 18 rows are required for VA SKUs. Based on these values, and the assumption that aisles in the same column must be the same length and width, the floorplan illustrated in Figure 5.1 has been developed.

5.2.2 Hybrid Forward Department

The only opportunity to reduce space requirements in the forward department is through consolidation with the hybrid items. As discussed earlier, since the forward department employs a dedicated layout, neither the exclusive NVA ($N\overline{H}$) nor VA items ($V\overline{H}$) can be

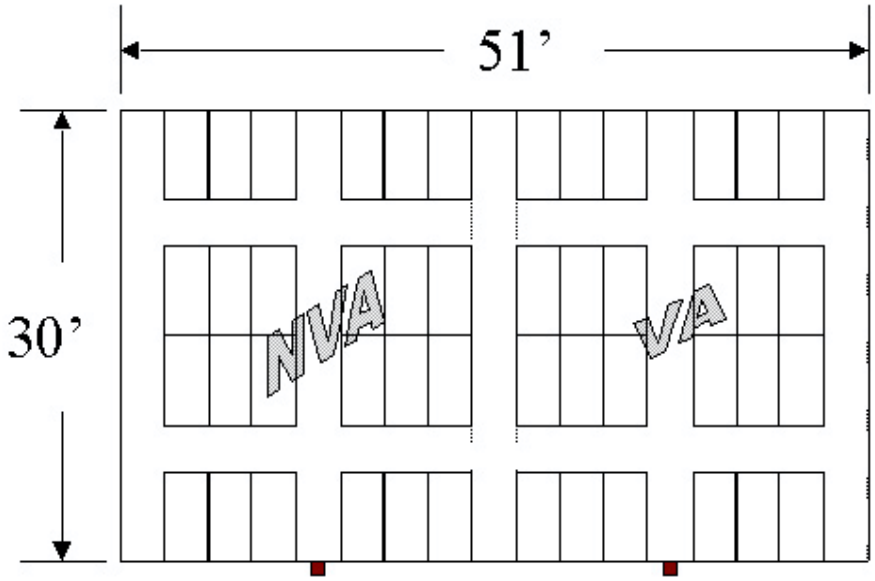

Figure 5.1: Floorplan for Two Separate Forward Departments.

combined to save space. However, hybrid SKUs can be combined in one area, which saves space over having the same item located in two departments.

To solve the problem of sizing the forward department, the decision-maker must provide the number of rows required for each hybrid SKU in each of the two separate areas and the number of rows required for each hybrid SKU if stored in the hybrid area. Obviously, we are assuming that the number of rows required under the hybrid option is less than the two values combined under the two separate areas option[1]. This concept is illustrated in the context of our running example problem.

Our equation to find the maximum space requirement over the 8-week period for the hybrid forward departments is as follows:

$$S_f^2 = \sum_{i \in HY} \max_t \{I_f^{it}\} + \sum_{i \in N\overline{H}} \max_t \{I_f^{it}\} + \sum_{i \in V\overline{H}} \max_t \{I_f^{it}\}, \tag{5.3}$$

[1]If this were not the case, there would be no advantage – and in fact, there would be a disadvantage — associated with doing so.

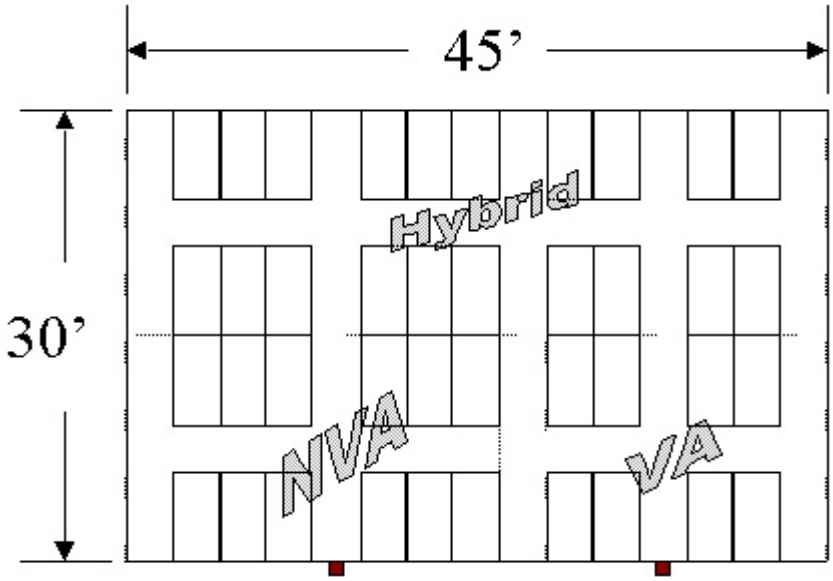

Figure 5.2: Floorplan for the Hybrid Forward Department.

where I_f^{it} is the number of rows required for the appropriate set of SKUs. The warehouse area must then be related to this space requirement. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

Hybrid Forward Department — Example Problem

To determine the space requirement for hybrid forward departments we must find the maximum inventory level for the hybrid SKUs ($HY = \{1\text{–}4\}$), NVA SKUs ($N\overline{H} = \{5\text{–}8\}$), and VA SKUs ($V\overline{H} = \{9\text{–}12\}$). Table 5.1 presented the number of rows dedicated for hybrid SKUs (HY) and Table 5.2 presented the number of rows dedicated in the forward department for non-hybrid SKUs.

In this example, 14 rows are required for hybrid SKUs, 12 rows are required for NVA SKUs, and 8 rows are required for VA SKUs. Based on these values, and the assumption that aisles in the same column must be the same length and width, the floorplan illustrated in Figure 5.2 was developed.

5.3 Forward Department Retrieval

It is important to note that there is a significant difference between the forward and reserve departments in terms of retrieval tour calculations. In the reserve department, cases are typically stored in the closest open location at the time. Given that cases are stored in a stochastic manner, the closest open location's distribution appears uniform over the department [17].

On the other hand, in the forward department, DCs dedicate particular locations to each SKU. In addition, DCs tend to organize the forward department so that like items are near each other. In the apparel industry, garments are typically grouped by size, style, or color. In general, all industries use slotting algorithms in the forward department to take advantage of the inter-item correlations to reduce travel distances. This causes the distribution of cases to not be uniform across the forward department. This can be accounted for by using the appropriate value of s in our application of Caron's algorithm.

5.3.1 Forward Department — Caron's Algorithm

Caron's algorithm assumes that the picker follows a traversal strategy. Figure 4.4 illustrates how the traversal strategy would route a picker through a series of points in a warehouse. The aisles are organized into two columns of aisles in Figure 4.4. Column A contains aisles $1-4$, and column B contains aisles $5-8$. The picker must travel the entire length of any aisle containing at least one pick. Aisles are served from front to back down one column of aisles and then back to front down the other column of aisles. It is important to note that Caron's algorithm assumes negligible aisle width, so items from both sides of an aisle can be retrieved from the centerline of the aisle. This is illustrated in aisle 1 of Figure 4.4.

As mentioned in Section 4.3.1, Caron's algorithm does not apply the traversal strategy when an odd number of aisles are visited. Caron *et al.* [5] asserts that when an odd number of aisles are visited, a routing policy with an even number of completely traversed aisles and

return travel in the aisle with the largest gap should be employed. Figure 4.6 illustrates how an operator would be routed in the same situation under Caron's algorithm. Caron *et al.* [5] presents the following analytical function that describes the COI-based ABC curve:

$$F(x) = \frac{(1+s)\cdot x}{s+x}, \tag{5.4}$$

where x indicates the ratio of required storage space to total storage space, and s is the ABC shape factor. In (5.4), $F(x)$ represents the fraction of total warehouse activity associated with x. Table 4.5 presents shape factors for various ABC curves. Since slotting algorithms are employed in the forward department, different values of s are required for each case, based on the ABC curve. The value of s for a particular ABC curve can be calculated by solving for s in (5.4) with known values of x and $F(x)$.

Caron's algorithm breaks tours into longitudinal and lateral distance. An equation for expected travel for the forward department is as follows [5]:

$$E[D_f] = E[D_f^{lat}] + E[D_f^{long}]. \tag{5.5}$$

An approximation for the expected longitudinal distance (between aisle travel) is [5]:

$$E[D_f^{long}] = 2\cdot\sum_{j=2}^{a/2}\left(w_I\cdot(j-1)\left\{\left[F\left(\frac{2\cdot j}{a}\right)\right]^N - \left[F\left(\frac{2\cdot j-2}{a}\right)\right]^N\right\}\right). \tag{5.6}$$

An approximation for the expected lateral distance (within aisle travel) is as follows for the forward department [5]:

$$E[D_f^{lat}] = (l+w_E)\cdot\sum_{i=1}^{a}\left(1-\left\{1-\left[F\left(\frac{i}{a}\right)-F\left(\frac{i-1}{a}\right)\right]\right\}^N\right). \tag{5.7}$$

5.3.2 Forward Department — Example

The algorithm presented has been used to evaluate the data for our example problem. I/O points have been assumed to be located at the bottom center of each area analyzed.

Table 5.3 illustrates the values used in the calculation for the separate forward department layout. Values for s were calculated using a 63/37.5 curve for the NVA area, and a 61/37.5 curve for the VA curve. Expected longitudinal distance was calculated using (5.6). Expected lateral distance was calculated using (5.7). Based on (5.5) the separate forward department has a total expected travel distance ($E[D_f]$) of 92.5 ft.

Table 5.3: Input to Caron's Algorithm for the Separate Forward Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	4	20	9	15	3	0.544
VA	4	20	9	15	3	0.622

Our hybrid layouts for our NVA and VA areas violate the distribution of items assumed by Caron *et al.* [5]. That is, the model developed by Caron *et al.* [5] assumes a standard ABC curve is used to obtain the shape factor s. However, our hybrid layout requires us to calculate the expected distance for tours that traverse the NVA and HY areas (or the VA and HY areas). Such a situation results in a distribution of demand over the forward department that cannot be represented by a standard ABC curve. A comparison of the cumulative distribution of items for a standard ABC curve and a hybrid layout is presented in Figure 5.3, where the "jump" in the hybrid layout distribution curve occurs as one enters the hybrid area of the layout. Because of this difference in distribution curves, simulation must be used to evaluate the initial hybrid layout. Based on the simulation performed, our initial hybrid forward department has a total expected travel time of 98.3 ft. Appendix A presents the individual replication results for our simulation of the initial hybrid forward department.

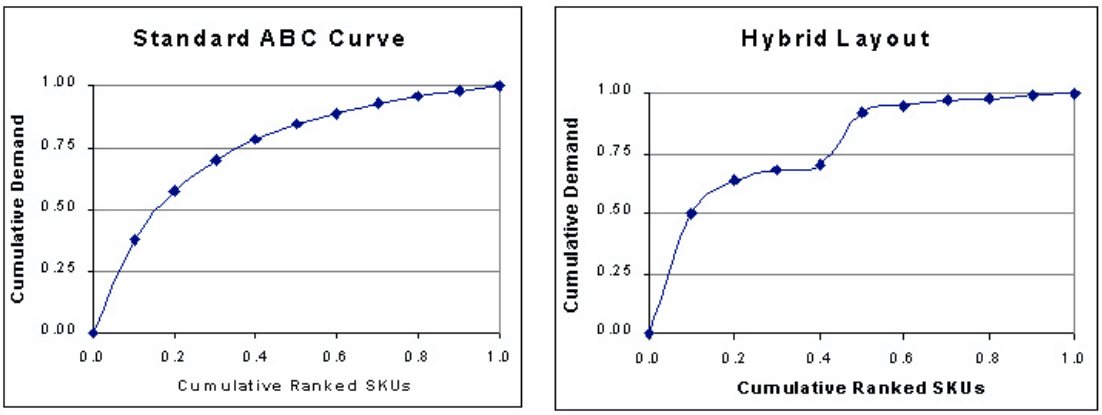

Figure 5.3: Comparison of the Cumulative Distribution of Items for a Standard ABC Curve and a Hybrid Layout.

5.4 Hybrid Tradeoff Analysis

The layouts we have developed thus far are the separate and initial hybrid. The separate layout divides the forward department into VA and NVA departments. This layout has low putaway and replenishment costs due to short retrieval times, but requires a large amount of floorspace.

The initial hybrid layout places all of the hybrid items in a separate department that is easily accessible to the VA and NVA areas. This layout assumes that all hybrid items should be stored in the hybrid area. However, if a SKU has a high turnover, it should be moved from the hybrid area to the NVA/VA areas of the warehouse, where it would be close to the I/O point and reduce travel distance.

As mentioned in section 5.3.2, our hybrid layouts for our NVA and VA areas violate the distribution of items assumed by Caron *et al.* [5]. Caron *et al.* [5] assumes a single ABC curve is used to obtain the shape factor s. However, our hybrid layouts requires us to calculate expected distance for tours which traverse the NVA and HY areas, and the VA and HY areas. This violation requires us to modify our tradeoff methodology used in the reserve department for application in the forward department.

1. **Hybrid SKUs are ranked in order of turnover ratio.**

2. **The HY SKU with the highest turnover ratio is selected and added to the NVA/VA areas of the department** – The SKU with the largest turnover ratio has the largest demand to inventory ratio. Hence, a SKU with a high turnover ratio will experience a large decrease in retrieval time when it is moved to the NVA/VA departments. We refer to the selected SKU as H.

3. **Calculate forward department area based on the space requirement (S_f^3) for the hybrid layout** – The equation for forward department area is as follows:

$$S_f^3 = \max_t \sum_{i \in N\overline{H}+H} I_f^{it} + \max_t \sum_{i \in V\overline{H}+H} I_f^{it} + \max_t \sum_{i \in HY-H} I_f^{it}. \tag{5.8}$$

   The warehouse area for the hybrid layout must then be related to S_f^3. A floorplan is developed based on the horizontal aisle structure that includes aisles for operator travel. Columns of aisles are assumed to be the same length and width.

4. **Run a simulation based on the new SKU location and department layout** – This step is performed to obtain an estimate of the retrieval time.

5. **Calculate cost** – Total cost can be calculated using (3.1).

6. **Update inventory and area values** – set $N\overline{H} = N\overline{H} + H$; $V\overline{H} = V\overline{H} + H$; and $HY = HY - H$. $E[D_f^{N\overline{H}}]$, $E[D_f^{V\overline{H}}]$, and reserve department area (A_f) should be set to the updated values.

7. **Continue until all hybrid SKUs are examined** – Due to the discrete nature of our department layout, fluctuations in area require us to evaluate every hybrid SKU. The hybrid tradeoff layout with the lowest total cost should be selected.

5.4.1 Hybrid Tradeoff Analysis Example

A hybrid tradeoff analysis has been performed for the sample problem. The following cost and demand data was obtained for the forward department.

- 1,600,000 picks/year are expected for the facility
- 20 picks/tour (on average)
- operators are paid $35,000/year
- a warehouse cost of $5/ft^2 has been estimated
- the average operator works 1680 hours/year (35 hours/week $\times$ 48 weeks/year)
- walking speed is 4 ft/sec (2.7 mph)

Table 5.4 presents the SKUs for the forward department ranked in order of turnover.

Table 5.4: SKUs Ranked by Turnover.

SKU		**Avg. Inv (Cases)**	**Demand**	**Turnover**
2	HY	230	478.96	2.08
5	NVA	150	75.06	0.50
1	HY	75	34.40	0.46
8	NVA	255	109.18	0.43
9	VA	130	49.35	0.38
3	HY	115	42.82	0.37
4	HY	160	59.00	0.37
10	VA	80	29.11	0.36
12	VA	110	38.05	0.35
6	NVA	100	31.49	0.31
11	VA	85	25.45	0.30
7	NVA	95	27.13	0.29

The *HY* SKU with the highest turnover is added to the NVA/VA areas of the department. Based on the data presented in Table 4.10, SKU 2 has the highest turnover (2.08) of the four SKUs currently located in the hybrid area. Moving SKU 2 from the hybrid department

to the NVA/VA departments gives us a layout that is 1350 ft^2 (an increase of 0 ft^2) and has a total average distance of 97.5 ft (a decrease of 0.8 ft). Based on the cost and demand data obtained, the total cost of our warehouse is $\$12,392$, which is an improvement over our layout with all hybrid items stored in the hybrid department ($\$12,439$).

The next *HY* SKU with the highest turnover is added to the NVA/VA areas of the department. Based on the data presented in Table 4.10, SKU 1 has the highest turnover (0.46) of the three SKUs still remaining in the hybrid area. Moving SKU 1 from the hybrid department to the NVA/VA departments gives us a layout that is 1350 ft^2 (an increase of 0 ft^2, since no additional rows are added to either area) and has a total average distance of 97.2 ft (a decrease of 0.3 ft). Based on the cost and demand data obtained, the total cost of our warehouse is $\$12,375$, which is an improvement over our previous layout ($\$12,392$).

SKU 3 has the highest turnover (0.37) of the two SKUs still remaining in the hybrid area. Moving SKU 3 from the hybrid department to the NVA/VA departments gives us a layout that is 1530 ft^2 (an increase of 180 ft^2) and has a total average distance of 93.3 ft (a decrease of 3.9 ft). Based on the cost and demand data obtained, the total cost of our warehouse is $\$13,049$, which is more expensive than our layout with only SKUs 1 and 2 located in the NVA/VA areas ($\$12,375$).

Moving SKU 4 to the non-hybrid areas of our forward department would result in a hybrid layout with no hybrid area (i.e., a separate layout). Therefore, SKU 3 is the final SKU we need to analyze. In the reserve department analysis we tested the accuracy of our methodology by calculating the expected distance for our hybrid tradeoff with all 4 SKUs moved to non-hybrid areas. Since we have used simulation for our hybrid tradeoff analysis in the forward department, instead of the expected distance estimate that was used in the reserve department, there is no need to perform this final tradeoff calculation. A summary of the results for our example problem is presented in Table 5.5.

It is important to note that the values for department area stayed the same for our hybrid tradeoffs until SKU 3 was moved to the NVA/VA area. When SKU 3 was moved our value

Table 5.5: Results of the Hybrid Tradeoff Simulations for the Forward Department (ft).

		Distance/Tour	**Percent of Demand**	**Total Dist/Tour**	**Area**
Separate	NVA	91.18	0.55	91.3	1530
	VA	91.50	0.45		
Initial Hybrid	NVA	96.68	0.55	98.3	1350
	VA	100.37	0.45		
SKU 2 in NVA/VA	NVA	96.58	0.55	97.5	1350
	VA	98.70	0.45		
SKUs 2+1 in NVA/VA	NVA	96.31	0.55	97.2	1350
	VA	98.40	0.45		
SKUs 2,1,+3 in NVA/VA	NVA	98.43	0.55	93.3	1530
	VA	87.00	0.45		

for forward department area jumped to 1530 ft^2 (an increase of 180 ft^2). This is due to the fact that we developed a discrete layout with a fixed aisle structure. Our layout had enough space to account for SKUs 2 and 1, but when SKU 3 was added another aisle was needed in the layout to account for the increase in required inventory. It is for this reason that our hybrid tradeoff analysis must consider adding each item so that the discreteness of our area units do not overly influence our results.

Appendix A presents the individual replication results for our simulation of the different hybrid forward department layouts.

5.5 Forward Department — Comparison of Results

Table 5.6 presents a summary of the area required for each of our alternatives. As was expected, the separate layout required the most area.

Table 5.6: Comparison of the Area Required for the Forward Layouts.

	Area (ft^2)
Initial Hybrid	1350
SKU 2 added to NVA/VA	1350
SKUs 1 & 2 added to NVA/VA	1350
SKUs 1,2,&3 added to NVA/VA	1530
Separate	1530

Results from the distance calculations performed on the test data are presented in Table 5.7.

The separate layout had the shortest travel distance of all the cases, and the combined layout had the longest travel distance in all cases.

Table 5.7: Comparison of Distance Results for the Forward Department.

	Distance/Tour (ft)	**% of Max**
Separate	91.3	92.9%
SKUs 1,2,&3 added to NVA/VA	93.3	94.9%
SKUs 1 & 2 added to NVA/VA	97.2	98.9%
SKU 2 added to NVA/VA	97.5	99.2%
Initial Hybrid	98.3	100.0%

This example provided us with the results that we expected. Namely, the separate forward department layout provided us with the shortest travel distances, but had the largest forward department size. The hybrid layouts provided us with good values for both travel distance and forward department size as expected.

Table 5.8 presents the cost results for the forward department. Our hybrid layout where SKUs 2 and 1 have been moved to the NVA/VA areas has the lowest total cost ($\$12,375$). The separate layout has the lowest labor cost ($\$5,284$), but the highest warehouse area cost ($\$7,650$).

Table 5.8: Cost Results for the Forward Department.

	Labor Cost	**WH Cost**	**Total Cost**
SKUs 1&2 moved to NVA/VA	$5,625	$6,750	$12,375
SKU 2 moved to NVA/VA	$5,642	$6,750	$12,392
All in Hybrid	$5,689	$6,750	$12,439
Separate	$5,284	$7,650	$12,934
SKUs 1,2,&3 moved to NVA/VA	$5,399	$7,650	$13,049

Chapter 6

Additional Example Problems

The 12-SKU example problem presented in previous sections provides an excellent overview to the methodology for our research. However, it has obvious shortcomings from a validity standpoint, since a typical warehouse contains more than 12 SKUs. To extend our research, the following chapter provides three additional example problems to cover situations that may possibly be encountered in practice.

We study a reserve department with 300 SKUs, and an 80/20 ABC curve. Cases are 2' x 2' x 3' in dimension. Aisles are 8' wide to account for operator travel. Cases can be stored 20 high in the reserve department.

The forward department also contains 300 SKUs, and follows an 80/20 ABC curve. Rows of cases are 2' x 6' x 9' in dimension, and store up to 9 cases of the same SKU. Aisles are 8' wide to account for 2-way operator travel.

We study four example problems in this chapter. Section 6.1 examines the reserve department of a warehouse based on data obtained from Cross Creek Apparel, Inc.'s main distribution center in Mt. Airy, NC. Section 6.2 examines the reserve department of a warehouse with an equal split of SKUs. Section 6.3 examines the forward department of a warehouse with an equal split of SKUs. Section 6.4 examines the reserve department of a warehouse

where all the SKUs are hybrid. Only one forward department was examined due to the number of simulations required for the hybrid tradeoff analysis in the forward department.

6.1 Example Based on Cross Creek Data

The following example is based on data obtained from Cross Creek Apparel, Inc. A majority of the SKUs in the warehouse are NVA. The remaining SKUs are hybrid. No SKU in the warehouse is VA-only. This example follows the methodology developed in Chapter 4.

6.1.1 Example Problem Data

In the reserve department, 69% of the SKUs are NVA. The remaining 31% of the SKUs are HY. Appendices B and C present the inventory levels for the 300 SKUs over an 8-week period. Items with the same demand may have different inventory levels due to the fluctuation in inventory level over time. Operators earn $\$35,000$/year, and floorspace costs $\$5/\text{ft}^2$.

6.1.2 Reserve Storage Department

The first value to determine for this problem is the reserve department space requirement, as presented in Section 4.2. The space requirement for an area can be defined using (4.1).

Combined Reserve Department

The space requirement for the combined reserve department can be defined using (4.2). When this is applied to the data presented in Appendix B, a space requirement of 39,824 for the combined reserve department is obtained. The layout developed based on this information has 26 aisles of cases. There are 1,560 cases stored in each aisle. Figure 6.1 illustrates the

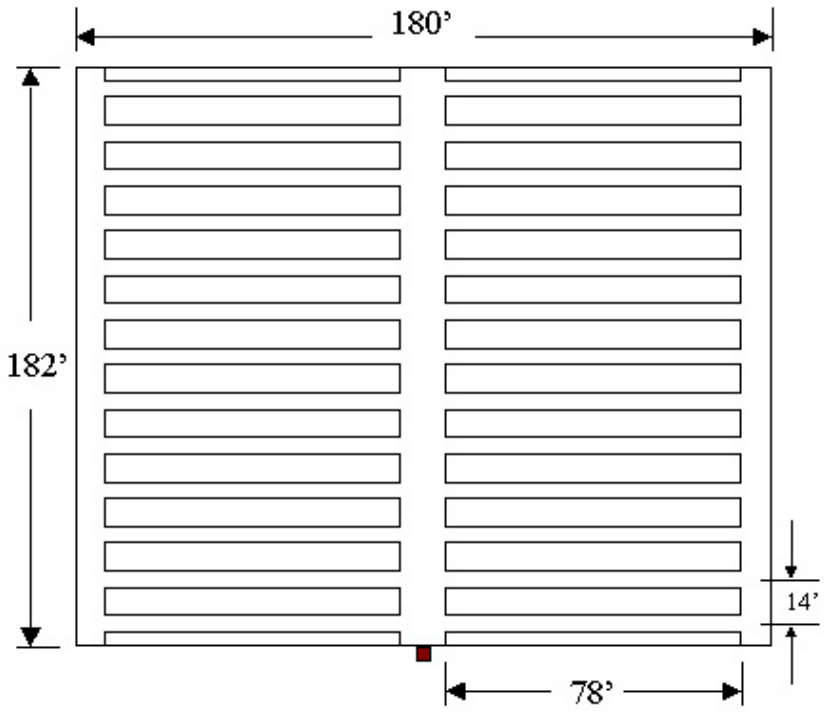

Figure 6.1: Floorplan for the Combined Reserve Department in the Cross Creek Example.

floorplan for the reserve department in the Cross Creek example. This layout requires a total area of 32,760 ft^2.

Separate Reserve Department

The space requirement for the separate reserve department can be defined using (4.3). When this is applied to the data presented in Appendix C, a space requirement of 31,292 is determined for the NVA area, and 22,807 is determined for the VA area. The layout developed based on this information has 22 aisles of cases in both the NVA and VA areas (although the length of the aisles in the VA area is proportionally smaller). Figure 6.2 illustrates the floorplan for the reserve department in the Cross Creek example. This layout requires a total area of 44,352 ft^2.

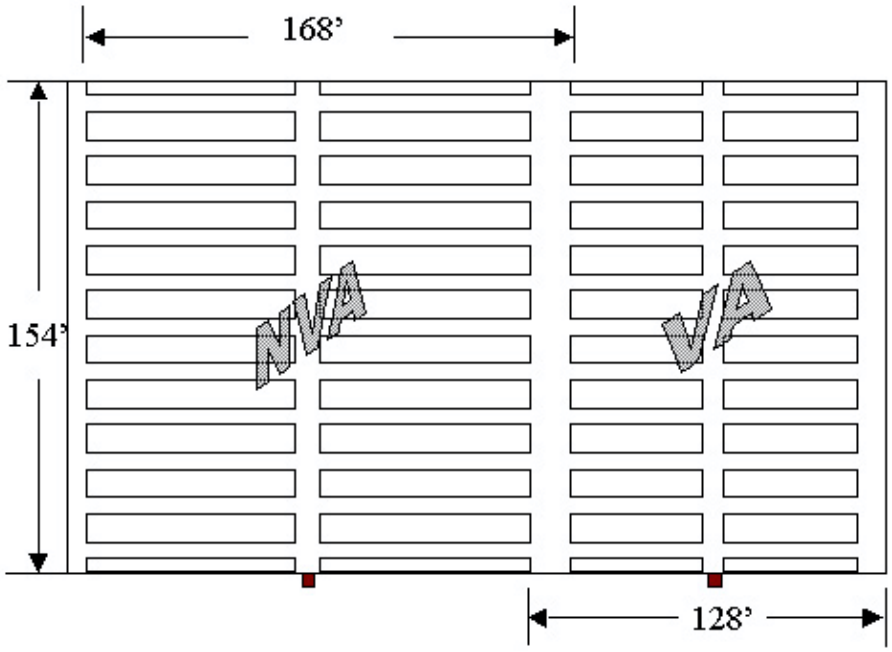

Figure 6.2: Floorplan for the Separate Reserve Department in the Cross Creek Example.

Initial Hybrid Reserve Department

The space requirement for the initial hybrid reserve department can be defined using (4.4). When this is applied to the data presented in Appendices B and C, a space requirement of 12,149 cases is determined for the NVA area, and 30,367 cases is determined for the hybrid area. There is no VA space requirement, since every SKU required for VA operations can also be ordered as a NVA item, and thus is stored in the hybrid area of the reserve department. The layout developed based on this information has 20 aisles of cases in both the NVA and VA areas (although the length of the aisles in the VA area is proportionally smaller). Figure 6.3 illustrates the floorplan for the reserve department in the Cross Creek example. The I/O point at the bottom of the hybrid area is used for VA orders since there is no VA area in our initial hybrid layout. This layout requires a total area of 35,840 ft^2.

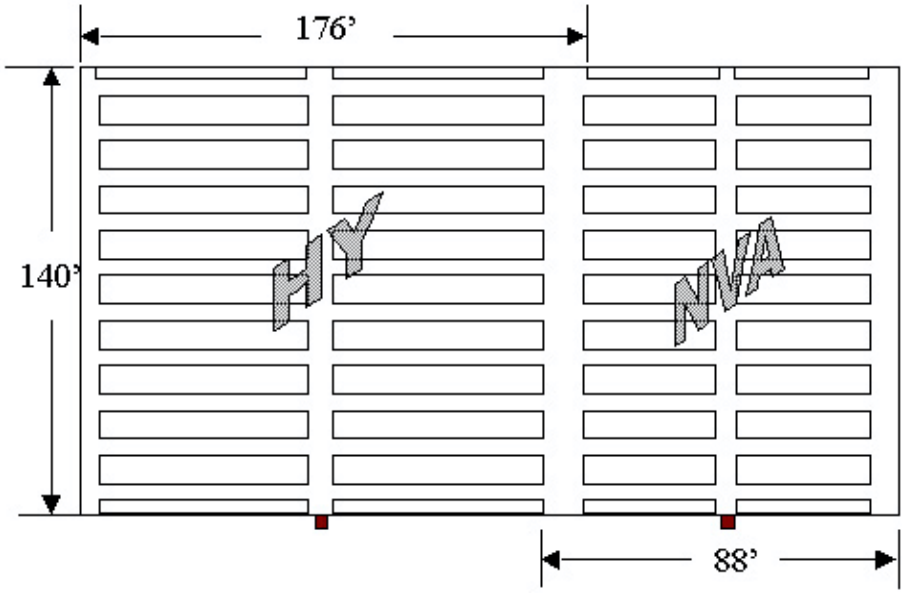

Figure 6.3: Floorplan for the Initial Hybrid Reserve Department in the Cross Creek Example.

6.1.3 Reserve Department Retrieval

In this section we calculate the average expected distance for a tour in the warehouse. The algorithm used to calculate expected distance was presented in Section 4.3.

Table 6.1 illustrates the values used in the calculation for the combined reserve department layout. The combined reserve department has a total expected travel distance of 1,544.7 ft.

Table 6.1: Input to Caron's Algorithm for the Combined Reserve Department (ft).

aisles (a)	N	l_I	w_I	w_E	s
26	20	78	14	8	99999

Table 6.2 presents the values used in the calculation for the separate reserve department layout. The separate reserve department has a total expected travel distance of 1,314.5 ft.

Our hybrid layouts for our NVA and VA areas violate the rectangular layout assumed by Caron *et al.* [5]. Because of this violation, aisles must be moved to extend the pair of columns of aisles for our calculation. Aisles are moved so they minimize the number of additional

Table 6.2: Input to Caron's Algorithm for the Separate Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	22	20	72	14	8	99999
VA	22	20	52	14	8	99999

aisles created, while providing at least as much storage space as our initial hybrid layout. An example of this is illustrated in Figure 4.8.

This method of extending columns assumes even demand levels between HY and NVA areas of the reserve department. It should be noted that if there is a large discrepancy between HY demand and NVA demand, extending our columns of aisles does not provide an accurate solution.

Table 6.3 illustrates the values used in the calculation for the initial hybrid reserve department layout. The I/O point at the bottom of the hybrid area is used for VA orders since there is no VA area in our initial hybrid layout. NVA orders still begin and end at the I/O point at the bottom of the NVA area. The initial hybrid reserve department has a total expected travel distance of 1,497.8 ft. Table 6.4 presents a summary of the results of the calculation for the reserve department.

Table 6.3: Input to Caron's Algorithm for the Initial Hybrid Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA+HY	68	20	32	14	8	99999
VA+HY	20	20	76	14	8	99999

Table 6.4: Results of the Calculations using Caron's Algorithm for the Reserve Department (ft).

		Distance/Tour	**Percent of Demand**	**Total Dist/Tour**	**Area**
Combined	All	1544.7	100%	1544.7	32760
Separate	NVA	1341.1	90%	1314.5	44352
	VA	1074.7	10%		
Initial Hybrid	NVA	1588.8	90%	1497.8	35840
	VA	679.1	10%		

6.1.4 Hybrid Tradeoff Analysis for the Reserve Department

The three layouts we have developed thus far are the combined, separate and initial hybrid. The combined layout minimizes warehouse space (32,760 ft^2), but has high order retrieval times (1,544.7 ft). The separate layout divides the reserve department into VA and NVA departments. This reduces putaway and replenishment costs due to shorter retrieval times (1,314.5 ft), but requires more overall space (44,352 ft^2).

The initial hybrid layout places all of the hybrid items in an area of the reserve department that is separate from the NVA area. This layout assumes that all hybrid items should be stored in the hybrid area. However, if a SKU has a high turnover, it should be moved from the hybrid area to the NVA/VA areas of the warehouse, where it would be close to the I/O point and reduce travel distance. When the first hybrid item is moved to the non-hybrid areas, a VA department must be created, since one is not included in the initial hybrid layout.

The results presented in Appendix D were obtained by following the hybrid tradeoff methodology from Section 4.4. Cost continued to decrease for our hybrid tradeoffs until SKU 240 was moved to the VA/NVA areas of the reserve department. When SKU 240 was moved our value for forward department area jumped to 36,400 ft^2 (an increase of 560 ft^2). This is due to the fact that we developed a discrete layout with a fixed aisle structure. Our layout had enough space to account for the previous 31 SKUs, but when SKU 240 was added another aisle was needed in the layout to account for the increase in required inventory. Due to the discrete nature of our layout, we have calculated tradeoffs for every hybrid SKU in the reserve department.

6.1.5 Cross Creek Example — Comparison of Reserve Department Results

Table 6.5 presents a summary of the area required for each of our alternatives. As was expected, the combined layout required the least area, while the separate layout required the most area.

Table 6.5: Comparison of the Area Required for the Cross Creek Example.

	Area (ft^2)
Combined	32760
Initial Hybrid	35840
HY Tradeoff	35840
Separate	44352

Results from the distance calculations performed on the test data are presented in Table 6.6. The separate layout had the shortest travel distance of all the cases, and the combined layout had the longest travel distance in all cases.

Table 6.6: Comparison of Distance Results for the Cross Creek Example.

	Distance/Tour (ft)	**% of Max**
Separate	1314.50	85.1%
HY Tradeoff	1490.05	96.5%
Initial Hybrid	1497.83	97.0%
Combined	1544.71	100.0%

Table 6.7 presents the cost results of the Cross Creek Example. The separate layout has the lowest labor cost of all our options ($\$133,123$), but the highest warehouse cost of all our options ($\$221,760$). The combined layout has the lowest warehouse cost of all our options ($\$163,800$), but the highest labor cost of all our options ($\$156,438$). Our combined layout has the lowest cost of all our potential layouts ($\$320,238$). Cross Creek currently has a combined reserve department.

Table 6.7: Results of the Cross Creek Example (ft).

Layout	Total Dist/Tour	Area	Labor Cost	WH Cost	Total Cost
Combined	1544.71	32760	$156,438	$163,800	$320,238
HY Tradeoff	1490.05	35840	$150,902	$179,200	$330,102
Initial HY	1497.83	35840	$151,690	$179,200	$330,890
Separate	1314.50	44352	$133,123	$221,760	$354,883

6.2 Equal–SKU Split Example – Reserve Department

The following example is similar to our Cross Creek example, with the exception being that we have an equal number of NVA, VA, and HY SKUs. There are 100 NVA SKUs, 100 VA SKUs, and 100 HY SKUs. This example follows the methodology developed in Chapter 4.

6.2.1 Example Problem Data

Appendices E and F present the inventory levels for the 300 SKUs over an 8-week period. Items with the same demand may have different inventory levels due to the fluctuation in inventory level over time.

6.2.2 Reserve Storage Department

The first value to determine for this problem is the reserve department space requirement, as presented in Section 4.2. The space requirement for an area can be defined using (4.1).

Combined Reserve Department

The space requirement for the combined reserve department can be defined using (4.2). When this is applied to the data presented in Appendix E, a space requirement of 39,824 cases for the combined reserve department is obtained. The layout developed based on this information has 26 aisles of cases. There are 1,560 cases stored in each aisle. Figure

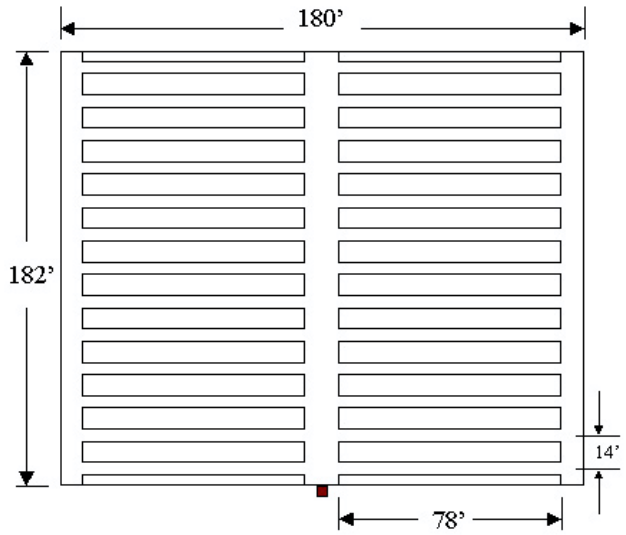

Figure 6.4: Floorplan for the Combined Reserve Department in the Equal–SKU Split Example.

6.4 illustrates the floorplan for the combined reserve department in the equal–SKU split example. This layout requires a total area of 32,760 ft^2.

Separate Reserve Department

The space requirement for the separate reserve department can be defined using (4.3). When this is applied to the data presented in Appendix F, a space requirement of 9,093 cases is determined for the NVA area, and 33,538 cases is determined for the VA area. The layout developed based on this information has 20 aisles of cases in both the NVA and VA areas (although the length of the aisles in the NVA area is proportionally smaller). Figure 6.5 illustrates the floorplan for the separate reserve department in the equal–SKU split example. This layout requires a total area of 35,840 ft^2.

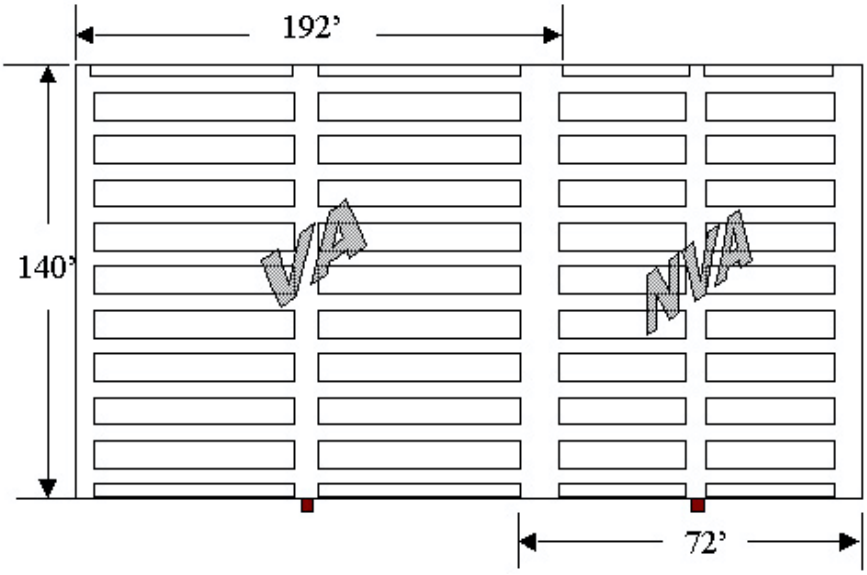

Figure 6.5: Floorplan for the Separate Reserve Department in the Equal–SKU Split Example.

Initial Hybrid Reserve Department

The space requirement for the initial hybrid reserve department can be defined using (4.4). When this is applied to the data presented in Appendices E and F, a space requirement of 5,060 cases is determined for the NVA area, 30,571 cases for the VA area, and 6,570 cases for the hybrid area. The layout developed based on this information has 20 aisles of cases in both the NVA and VA areas (although the length of the aisles in the NVA area is proportionally smaller). Figure 6.6 illustrates the floorplan for the initial hybrid reserve department in the equal–SKU split example. This layout requires a total area of 36,960 ft^2. This layout differs from the Cross Creek example since it requires a separate area for VA SKUs. The Cross Creek example did not need a VA area in the initial hybrid layout due to the fact that there were not any VA-only SKUs.

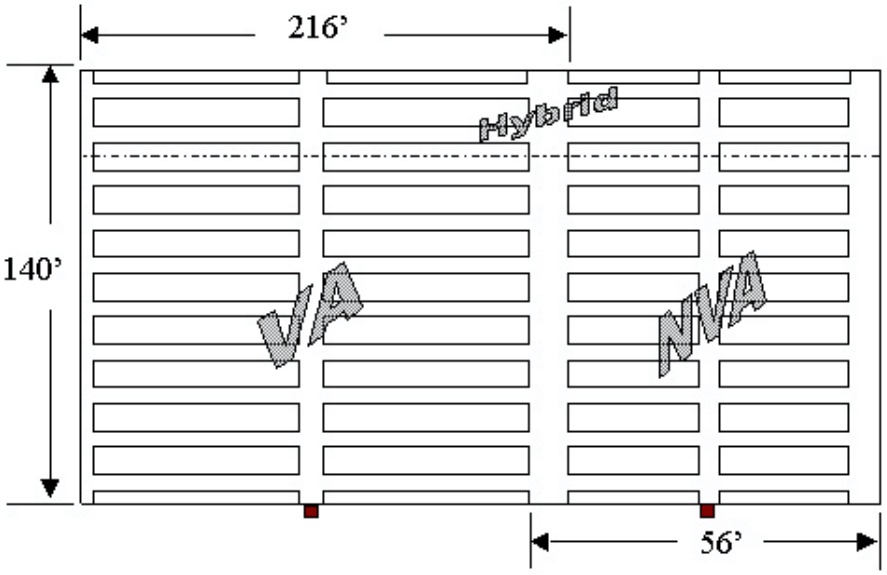

Figure 6.6: Floorplan for the Initial Hybrid Reserve Department in the Equal–SKU Split Example.

6.2.3 Reserve Department Retrieval

In this section we calculate the average expected distance for a tour in the warehouse. The algorithm used to calculate expected distance was presented in Section 4.3.

Table 6.8 illustrates the values used in the calculation for the combined reserve department layout. The combined reserve department has a total expected travel distance of 1,544.7 ft.

Table 6.8: Input to Caron's Algorithm for the Combined Reserve Department (ft).

aisles (a)	N	l_I	w_I	w_E	s
26	20	78	14	8	99999

Table 6.9 presents the values used in the calculation for the separate reserve department layout. The separate reserve department has a total expected travel distance of 1,197.7 ft.

Our hybrid layouts for our NVA and VA areas violate the rectangular layout assumed by Caron *et al.* [5]. Because of this violation, aisles must be moved to extend the pair of columns of aisles for our calculation. Aisles are moved so they minimize the number of additional

Table 6.9: Input to Caron's Algorithm for the Separate Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	20	20	24	14	8	99999
VA	20	20	84	14	8	99999

aisles created, while providing at least as much storage space as our initial hybrid layout. An example of this is illustrated in Figure 4.8.

This method of extending columns assumes even demand levels between HY and NVA areas of the reserve department. It should be noted that if there is a large discrepancy between HY demand and NVA demand, extending our columns of aisles does not provide an accurate solution.

Table 6.10 illustrates the values used in the calculation for the initial hybrid reserve department layout. The initial hybrid reserve department has a total expected travel distance of 1,497.8 ft. Table 6.11 presents a summary of the results for the reserve department.

Table 6.10: Input to Caron's Algorithm for the Initial Hybrid Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA+HY	66	20	26	14	8	99999
VA+HY	42	20	46	14	8	99999

Table 6.11: Results of the Calculations Using Caron's Algorithm for the Reserve Department (ft).

		Distance/Tour	**Percent of Demand**	**Total Dist/Tour**	**Area**
Combined	All	1544.7	100%	1544.7	32760
Separate	NVA	658.8	30%	1197.7	35840
	VA	1428.6	70%		
Initial Hybrid	NVA	1455.1	30%	1424.3	36960
	VA	1411.1	70%		

6.2.4 Hybrid Tradeoff Analysis for the Reserve Department

The three layouts we have developed thus far are the combined, separate and initial hybrid. In our previous examples, the initial hybrid layout had values for average distance and

warehouse area that fell between our values for the combined and separate layouts. In this example, our initial hybrid layout has an area of 36,960 ft^2, which is 1,120 ft^2 more than the value for our separate layout (35,840 ft^2). The hybrid layout is initially larger than the separate layout because the hybrid space requirement is small in comparison with the non-hybrid space requirements. The same number of cross over aisles are required for the hybrid area despite the low hybrid space requirement. Aisles are also not completely filled in the initial hybrid layout. This causes the area required to store hybrid items to be relatively large due to the space required by the aisle structure defined by Caron *et al.* [5]. However, due to the discrete nature of our approach, we must still perform the hybrid tradeoff analysis. The results presented in Appendix G were obtained by following the hybrid tradeoff methodology from Section 4.4. The least expensive hybrid tradeoff layout moves SKUs 270–255 to the non-hybrid areas of the forward department. The total cost of the hybrid tradeoff layout is $328,929.

6.2.5 Equal–SKU Split Example — Comparison of Reserve Department Results

Table 6.12 presents a summary of the area required for each of our alternatives. The combined layout required the least area, while the initial hybrid layout required the most area.

Table 6.12: Comparison of the Area Required for the Equal–SKU Split Example.

	Area (ft^2)
Combined	32760
Separate	35840
Initial Hybrid	36960
HY Tradeoff	36960

Results from the distance calculations performed on the test data are presented in Table 6.13. The separate layout had the shortest travel distance of all the cases, and the combined layout had the longest travel distance in all cases.

Table 6.13: Comparison of Distance Results for the Equal–SKU Split Example.

	Distance/Tour (ft)
Separate	1197.69
HY Tradeoff	1423.17
Initial Hybrid	1424.32
Combined	1544.71

Table 6.14 presents the results of the equal–SKU split example. The separate layout has the lowest labor cost of all our options ($\$121,294$). The combined layout has the lowest warehouse cost of all our options ($\$163,800$), but the highest labor cost of all our options ($\$156,438$). The separate layout has the lowest cost of all our potential layouts ($\$300,494$).

Table 6.14: Results of the Equal–SKU Split Example (ft).

	Total Dist/Tour	**Area**	**Labor Cost**	**WH Cost**	**Total Cost**
Separate	1197.69	35840	$121,294	$179,200	$300,494
Combined	1544.71	32760	$156,438	$163,800	$320,238
HY Tradeoff	1423.17	36960	$144,129	$184,800	$328,929
Initial HY	1424.32	36960	$144,245	$184,800	$329,045

6.3 Equal–SKU Split Example – Forward Department

The following example examines a forward department with an equal number of NVA, VA, and HY SKUs. There are 100 NVA SKUs, 100 VA SKUs, and 100 HY SKUs. This example follows the methodology developed in Chapter 5.

6.3.1 Example Problem Data

Appendices H and I present the inventory levels for the 300 SKUs over an 8-week period. Items with the same demand may have different inventory levels due to the fluctuation in inventory level over time.

6.3.2 Forward Storage Department

The first value to determine for this problem is the forward department space requirement, as presented in Section 5.2. The space requirement for an area can be defined using (5.1).

Separate Forward Department

The space requirement for the separate forward department can be defined using (5.2). When this is applied to the data presented in Appendices H and I, a space requirement of 444 rows is determined for the NVA area, and 496 rows is determined for the VA area. The layout developed based on this information has 10 aisles of cases in both the NVA and VA areas (although the length of the aisles in the NVA area is proportionally smaller). Figure 6.7 illustrates the floorplan for the separate reserve department in the equal–SKU split example. This layout requires a total area of 30,160 ft^2.

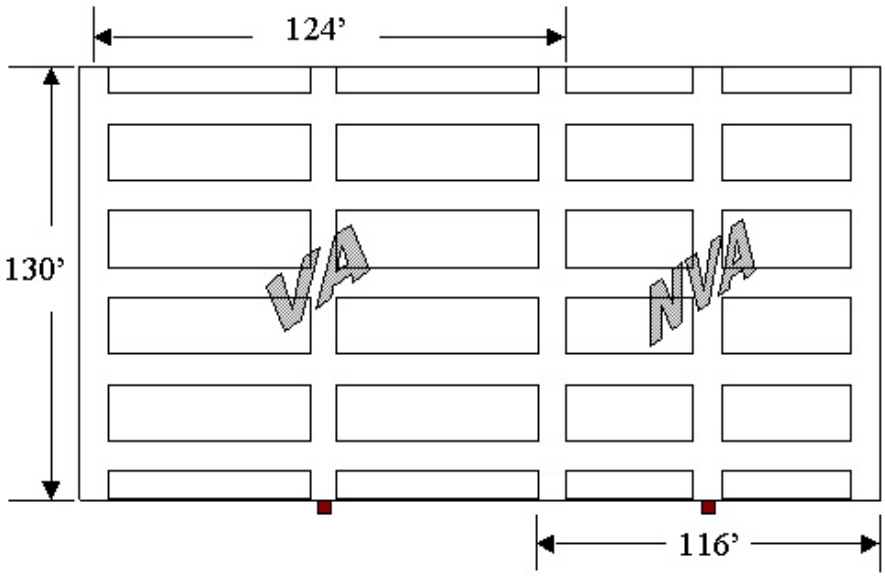

Figure 6.7: Floorplan for the Separate Forward Department in the Equal–SKU Split Example.

Initial Hybrid Forward Department

The space requirement for the initial hybrid reserve department can be defined using (5.3). When this is applied to the data presented in Appendix H, a space requirement of 238 rows is determined for the NVA area, 250 rows for the VA area, and 275 rows for the hybrid area. The layout developed based on this information has 6 aisles of cases in both the NVA and VA areas (although the length of the aisles in the NVA area is proportionally smaller). Figure 6.8 illustrates the floorplan for the initial hybrid reserve department in the equal–SKU split example. This layout requires a total area of 26,520 ft^2.

6.3.3 Forward Department Retrieval

In this section we calculate the average expected distance for a tour in the warehouse. The algorithm used to calculate expected distance for the forward department was presented in Section 5.3.

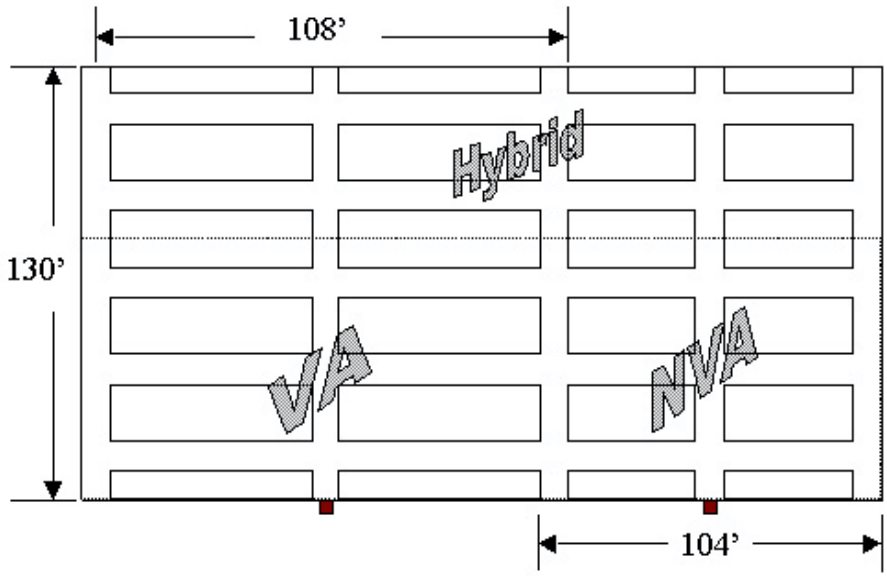

Figure 6.8: Floorplan for the Initial Hybrid Forward Department in the Equal–SKU Split Example.

Table 6.15 presents the values used in the calculation for the separate forward department. The separate forward department has an expected travel distance of 402.2 ft for the NVA area and 421.6 ft for the VA area.

Table 6.15: Input to Caron's Algorithm for the Separate Forward Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	10	20	46	26	8	0.07
VA	10	20	50	26	8	0.07

Our hybrid layouts for our NVA and VA areas violate the distribution of items assumed by Caron *et al.* [5]. Caron *et al.* [5] assumes a single ABC curve is used to obtain the shape factor s. However, our hybrid layout require us to calculate expected distance for tours which traverse the NVA and HY areas, and the VA and HY areas. Because of this violation, simulation must be used to evaluate the initial hybrid layout.

Our hybrid layout requires operators to travel within an "L-shaped" aisle structure similar to those presented in Figure 4.7. Due to limitations in the simulation model, we must modify our aisle structure to approximate between aisle travel for the hybrid layouts. This

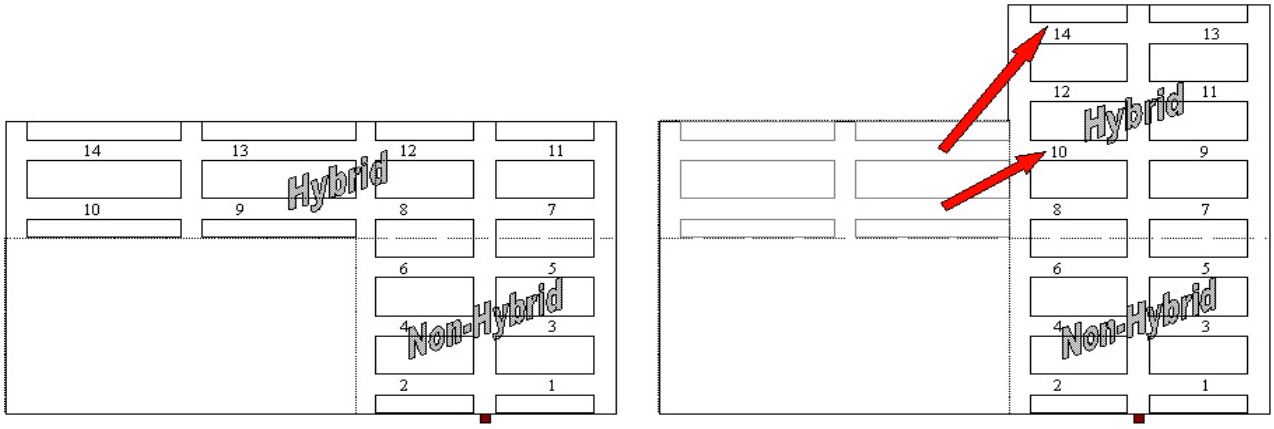

Figure 6.9: Illustration of the Method of Aisle Insertion for the Forward Department.

modification is similar to, but not the same as, the one performed in Section 4.3.2. The four hybrid aisles in the VA column of aisles must be inserted into the column of NVA aisles for our NVA simulation. Likewise, the four hybrid aisles in the NVA column of aisles must be inserted into the column of VA aisles for our VA simulation. This method of aisle insertion is illustrated in Figure 6.9.

This modification gives us approximate values for between–aisle travel distances in the hybrid aisles. When a high number of aisles are visited (as in our case) this estimate for changes in between–aisle distance are conservative. This change in between–aisle structure would not be valid for a smaller numbers of picks.

Based on the simulation performed, our initial hybrid forward department has an expected travel distance of 432.9 ft for the NVA area, and 420.6 ft for the VA area. Results of the simulations are presented in Appendix J.

6.3.4 Hybrid Tradeoff Analysis for the Forward Department

The layouts we have developed thus far are the separate and initial hybrid. The separate layout divides the forward department into VA and NVA departments. This layout has low putaway and replenishment costs due to short retrieval times, but requires a large amount

of floorspace.

The initial hybrid layout places all of the hybrid items in a separate department that is easily accessible to the VA and NVA areas. This layout assumes that all hybrid items should be stored in the hybrid area. However, if a SKU has a high turnover, it should be moved from the hybrid area to the NVA/VA areas of the warehouse, where it would be close to the I/O point and reduce travel distance.

Due to the time restrictions and scope of our research[1], we only examine the situation where SKUs are moved from the hybrid area to fill unassigned locations in the NVA/VA areas, without adding aisles to the existing layout. SKUs 270 and 219 (the hybrid SKUs with the highest turnover ratio) can be moved to the NVA/VA areas without making any changes to the aisle structure. This reduces our expected travel distance without increasing forward department size from the values for our initial hybrid area. The simulations performed required the same changes mentioned in the previous section for the initial hybrid layout.

Based on the simulation performed, our hybrid tradeoff layout has an expected travel distance of 432.9 ft for the NVA area, and 419.7 ft for the VA area. These values compare to 432.9 ft and 420.6 respectively, for the initial hybrid layout. Results of the simulations are presented in Appendix K.

6.3.5 Equal–SKU Split Example — Comparison of Forward Department Results

Table 6.16 presents a summary of the area required for each of our alternatives. The combined layout required the least area, while the initial hybrid layout required the most area.

Results from the distance calculations performed on the test data are presented in Table 6.17. The separate layout had the shortest travel distance of all three cases (415.81 ft/tour).

[1]Each simulation requires approximately 20 minutes of runtime.

Table 6.16: Comparison of the Area Required for the Forward Department of the Equal–SKU Split Example.

	Area (ft^2)
Initial Hybrid	26520
HY Tradeoff	26520
Separate	30160

Table 6.17: Comparison of Distance Results for the Forward Department of the Equal–SKU Split Example.

	Distance/Tour (ft)
Separate	415.81
HY Tradeoff	424.04
Initial Hybrid	424.31

Table 6.18 presents the results for the forward department of the equal–SKU split Example. The separate layout has the lowest labor cost of all our options ($\$24,063$). The hybrid layout has the lowest warehouse cost of our options ($\$132,600$). The hybrid tradeoff layout (with SKUs 270 and 219 moved to the non-hybrid areas) has the lowest cost of all our potential layouts ($\$157,139$), despite the fact that we did not examine all 100 potential hybrid tradeoffs.

Table 6.18: Results for the Forward Department of the Equal–SKU Split Example (ft).

	Total Dist/Tour	**Area**	**Labor Cost**	**WH Cost**	**Total Cost**
Separate	415.81	30160	$24,063	$150,800	$174,863
Initial HY	424.31	26520	$24,555	$132,600	$157,155
HY Tradeoff	424.04	26520	$24,539	$132,600	$157,139

It should be noted that the reserve department of the equal–SKU split example, our separate layout had the lowest cost ($\$300,494$). However, in the forward department, the hybrid tradeoff layout had the lowest cost of all our potential layouts ($\$157,139$). This illustrates a scenario where the requirements for the reserve and forward departments dictate two different organizational methods employed by the distribution center. The reserve department performs enough retrievals that it can justify dedicating the additional floorspace required to locate all the hybrid SKUs in the NVA and VA areas. The forward department in this

case does not place such a high premium on retrieval. Based on the information provided, it was determined less costly to reduce the amount of floorspace required at the expense of increased operator retrieval times. Typically it is desirable to minimize floorspace in a reserve department, and maximize operator efficiency in the forward department. This example shows that general statements with regard to what layouts are best for a department can be misleading.

6.4 All–Hybrid–SKU Example

The following example is similar to our Cross Creek example, with the exception being that all 300 SKUs are hybrid. This example follows the methodology developed in Chapter 4.

6.4.1 Example Problem Data

Appendices L and M present the inventory levels for the 300 SKUs over an 8-week period. Items with the same demand may have different inventory levels due to the fluctuation in inventory level over time.

6.4.2 Reserve Storage Department

The first value to determine for this problem is the reserve department space requirement, as presented in Section 4.2. The space requirement for an area can be defined using (4.1).

Combined Reserve Department

The space requirement for the combined reserve department can be defined using (4.2). When this formula is applied to the data presented in Appendix L a space requirement of 39,824 for the combined reserve department is obtained. The layout developed based on this

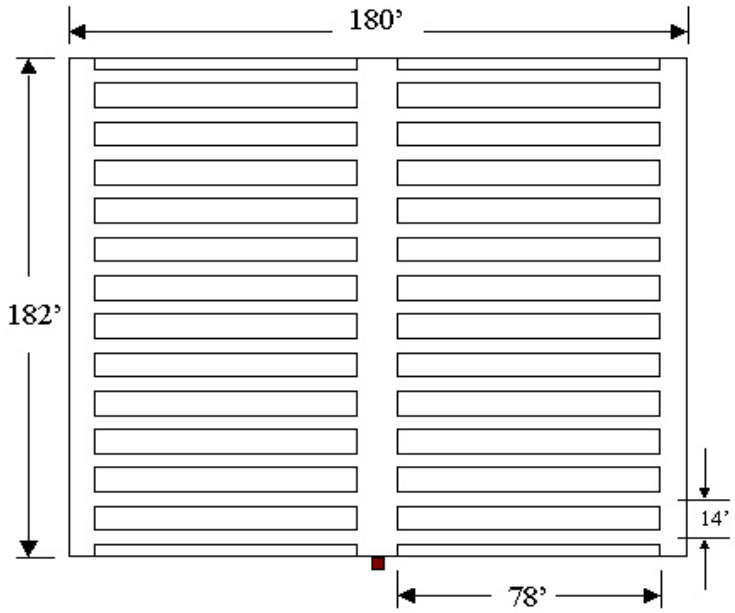

Figure 6.10: Floorplan for the Combined Reserve Department in the All–Hybrid–SKU Example.

information has 26 aisles of cases. There are 1,560 cases stored in each aisle. Figure 6.10 illustrates the floorplan for the reserve department in the all–hybrid–SKU example. This layout requires a total area of 32,760 ft^2.

Separate Reserve Department

The space requirement for the separate reserve department can be defined using (4.3). When this is applied to the data presented in Appendix M, a space requirement of 26,018 is determined for the NVA area, and 28,011 is determined for the VA area. The layout developed based on this information has 22 aisles of cases in both the NVA and VA areas. Figure 6.11 illustrates the floorplan for the reserve department in the Cross Creek example. This layout requires a total area of 44,352 ft^2.

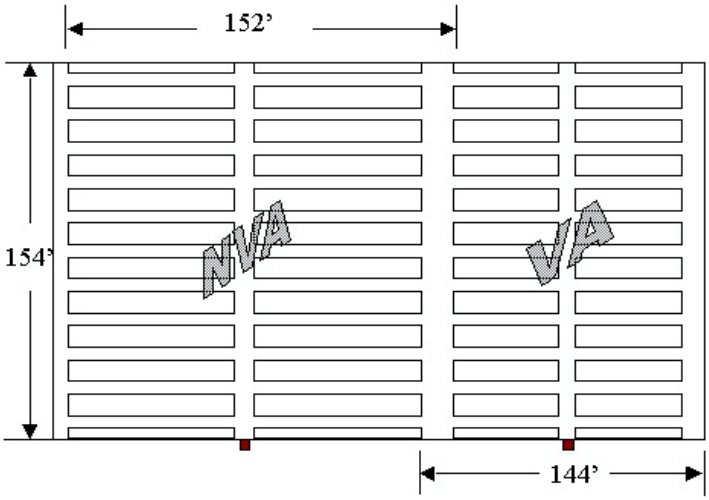

Figure 6.11: Floorplan for the Separate Reserve Department in the All–Hybrid–SKU Example.

Initial Hybrid Reserve Department

The space requirement and layout for the initial hybrid reserve department is the same as the combined reserve department since all the items in the warehouse are hybrid.

6.4.3 Reserve Department Retrieval

In this section we calculate the average expected distance for a tour in the warehouse. The algorithm used to calculate expected distance was presented in Section 4.3.

Table 6.19 illustrates the values used in the calculation for the combined reserve department layout. The combined reserve department has a total expected travel distance of 1,544.7 ft.

Table 6.19: Input to Caron's Algorithm for the Combined Reserve Department (ft).

aisles (a)	N	l_I	w_I	w_E	s
26	20	78	14	8	99999

Table 6.20 presents the values used in the calculation for the separate reserve department layout. The separate reserve department has a total expected travel distance of 1,314.5 ft.

Table 6.20: Input to Caron's Algorithm for the Separate Reserve Department (ft).

	aisles (a)	N	l_I	w_I	w_E	s
NVA	22	20	60	14	8	99999
VA	22	20	64	14	8	99999

The initial hybrid area of the reserve department has a total expected travel distance of 1,544.7 ft (the same as the combined reserve department). Table 6.21 presents the results of the calculations for the reserve department.

Table 6.21: Results of the Calculations Using Caron's Algorithm for the Reserve Department (ft).

		Distance/Tour	**Percent of Demand**	**Total Dist/Tour**	**Area**
Combined	All	1544.7	100%	1544.7	32760
Separate	NVA	1181.3	40%	1213.2	44352
	VA	1234.6	60%		
Initial Hybrid	All	1544.7	100%	1544.7	32760

6.4.4 Hybrid Tradeoff Analysis for the Reserve Department

The three layouts we have developed thus far are the combined, separate and initial hybrid. The combined layout minimizes warehouse space, but has high order retrieval times. The separate layout divides the reserve department into VA and NVA departments. This reduces putaway and replenishment costs due to shorter retrieval times, but requires more overall space.

The initial hybrid layout places all of the hybrid items in a separate department that is easily accessible to the VA and NVA areas. This layout assumes that all hybrid items should be stored in the hybrid area. However, if a SKU has a high turnover, it should be moved from the hybrid area to the NVA/VA areas of the warehouse, where it would be close to the I/O point and reduce travel distance.

The results presented in Appendix N were obtained by following the hybrid tradeoff methodology from Section 4.4.

This example examines the situation when a warehouse contains all hybrid items. When items are initially moved to the NVA/VA areas of the reserve department there is a huge increase in warehouse area. This is due to the fact that aisles must be set up to store a small number of NVA and VA SKUs. When more SKUs are moved to the non-hybrid areas our warehouse decreases in size, as aisles can be removed from the hybrid area. This fluctuation in reserve department size occurs throughout the hybrid tradeoff analysis. For this reason, moving all 300 SKUs should be examined, as we can not be sure if an absolute minimum is ever reached.

After examining all 300 SKUs, moving the first 160 SKUs (up to SKU 280) gives us the lowest cost for our hybrid layout. When SKU 280 was moved our value for reserve department area was 36,288 ft^2, and average distance per tour was 1,439.7.

6.4.5 All–Hybrid–SKU Example — Comparison of Reserve Department Results

Table A.1 presents the results for the all–hybrid–SKU example. The combined layout has the lowest warehouse cost of all our options ($\$163,800$), but the highest labor cost of all our options ($\$268,179$). The separate layout has the lowest labor cost of all our options ($\$210,632$), but the highest warehouse cost of all our options ($\$221,760$). Our hybrid tradeoff layout (up to SKU 280) has the lowest cost of all our potential layouts ($\$431,379$).

Table 6.22: Results for the All–Hybrid–SKU Example (ft).

	Total Dist/Tour	**Area**	**Labor Cost**	**WH Cost**	**Total Cost**
HY Tradeoff	1439.65	36288	$249,939	$181,440	$431,379
Combined	1544.71	32760	$268,179	$163,800	$431,979
Initial HY	1544.71	32760	$268,179	$163,800	$431,979
Separate	1213.24	44352	$210,632	$221,760	$432,392

Chapter 7

Conclusions and Future Research

7.1 Conclusions

The research we presented focused on how to best layout a warehouse to service both value added (VA) and no-value added (NVA) orders. In doing so, we are faced with a tradeoff between space utilization (facility costs) and replenishment times (labor costs). Ideally, we would like to maximize our space utilization, while minimizing replenishment times. Unfortunately, these goals are in conflict with each other, and a final solution requires a tradeoff between the two.

The two primary options we examined were to store all cases in a combined storage department or to store all VA/NVA cases in their own separate storage areas. The combined storage department will minimize storage space while the separate storage department will minimize retrieval costs. Another option we examined was using a hybrid area to store some of the cases, where the hybrid area holds cases that can fill both VA and NVA orders. We believe such an option may be useful in some situations.

The analyses presented considered reserve and forward departments. There is a major difference between the forward and reserve departments. In the reserve department, cases are

typically stored in the closest open location at the time. In the forward department, DCs dedicate particular locations to each stock-keeping unit (SKU). In addition, DCs tend to organize the forward department so that like items are near each other. These differences make the forward department much more difficult to examine. That is, where analytical models may be used successfully in the reserve department, simulation must be used to evaluate our hybrid layouts in the forward department.

Our work was designed to provide a tool for distribution centers (DCs) who face this decision of how to design their warehouse. This decision can occur many times over the life of a DC, as any changes in the balance between product demands require that the layout be re-evaluated. Based on the examples presented in previous chapters, we — not surprisingly — conclude the factors that have the biggest impact on the type of layout selected are the number of picks required and the cost of labor and floorspace. That is, doubling the number of retrievals in the reserve department would most likely shift the results from favoring a combined layout to favoring a separate layout in the reserve department. On the other hand, the ABC curve and aisle structure have a significant impact on total cost, but little effect on which layout option is selected in the reserve department. This is due to the fact that they affect each option in a similar manner.

In the forward department, the ABC curve plays a much larger role. Recall that the layout of the forward department is based on the skewness of the ABC curve, with A–items being placed closer to the input/output points, and C–items being placed further away. Therefore, in general, a higher degree of skewness favors the separate approach over the hybrid approach, especially with high labor rates and low space costs. For any analysis, simulation should be used to validate the recommended layout before implementing any changes.

7.2 Future Research

There are several opportunities for future research to extend what has been presented in this study. Caron's algorithm [5] bases its calculation on the assumption that items are stored based on a particular ABC curve. This assumption works well for combined and separate layouts, however simulation must be performed in the case of a hybrid layout. The NVA, VA and HY areas will almost always be represented by different ABC curves. The hybrid analysis requires us to calculate the expected distance over the NVA and HY areas, and the VA and HY areas. Thus, our hybrid layouts cannot be represented by a single ABC curve. This problem could be solved if Caron's algorithm [5] was changed to use a general probability distribution to specify whether an aisle was entered or not, instead of a specific ABC curve.

Another issue that was not focused on in our research was the number of items to store in each aisle. This value controls the length to width ratio of a department, which affects warehouse area and expected distance. In our analysis we tried to construct departments whose length and width were approximately equal, however there may be situations where it is less expensive to use an alternate layout. A study could be performed to determine the impact that changes in aisle size have on cost.

There were several times during our study when we were required to calculate the expected distance for an "L-shaped" aisle structure. These aisle structures were illustrated in Figures 4.7 and 6.9. Due to limitations in Caron's algorithm and the simulation model, we were forced to modify our aisle structure to approximate between–aisle travel. We believe that these approximations were fairly accurate, however, this problem could be solved more accurately with an improved simulation model or a modified expected distance algorithm.

Finally, what is eventually needed in this area is a computer program to produce layouts and their corresponding travel distances based on a set of product data and cost and demand specifications. Ideally, any possible layout the decision–maker develops could be evaluated

with an analytical model. This would allow a DC to be analyzed fairly quickly whenever changes in their operational requirements occur.

Bibliography

[1] Ackerman, K. B., Gardner, R. W., and Thomas, L. P., *Understanding Today's Distribution Center*, The Traffic Service Corporation (1972).

[2] Bassan, Y., Roll, Y., and Rosenblatt, M. J., "Internal Layout Design of a Warehouse," *IIE Transactions*, 12, 4, 317–322 (1980).

[3] Berry, J. R., "Elements of Warehouse Layout," *The International Journal of Production Research*, 7, 2, 105–121 (1968).

[4] Bozer, Y. A., *Optimizing Throughput Performance in Designing Order Picking Systems*, PhD thesis, Georgia Institute of Technology (1985).

[5] Caron, F., Marchet, G., and Perego, A., "Routing Policies and COI-Based Storage Policies in Picker-to-Part Systems," *International Journal of Production Research*, 36, 3, 713–732 (1998).

[6] Daganzo, C. F., "The Distance Traveled to Visit N Points with a Maximium of C Stops Per Vehicle: An Analytical Model and an Application," *Transportation Science*, 18, 331–350 (1984).

[7] Daganzo, C. F., "The Length of Tours in Zones of Different Shapes," *Transportation Research*, 18B, 135–145 (1984).

[8] de Koster, R., and van der Poort, E., "Routing Orderpickers in a Warehouse: A Comparison Between Optimal and Hueristic Solutions," *IIE Transactions*, 30, 5, 469–480 (1998).

[9] Frazelle, E. H., "Stock Location Assignment and Order Picking Productivity," Technical Report MHRC-TD-89-11, Material Handling Research Center (1990).

[10] Frazelle, E. H., Hackman, S. T., Passy, U., and Platzman, L. K., "The Forward - Reserve Problem," In *Optimization in Industry 2*, pp. 43–61. John Wiley and Sons Ltd (1994).

[11] Gibson, D. R., and Sharp, G. P., "Order Batching Procedures," *European Journal of Operational Research*, 58, 57–67 (1992).

[12] Goetschalckx, M., and Ratliff, H. D., "An Efficient Algorithm to Cluster Order Picking Items in a Wide Aisle," *Engineering Costs and Production Economics*, 13, 263–271 (1988).

[13] Goetschalckx, M., and Ratliff, H. D., "Order Picking in an Aisle," *IIE Transactions*, 20, 1, 53–62 (1988).

[14] Goetschalckx, M., and Ratliff, H. D., "Shared Storage Policies Based on the Duration Stay of Unit Loads," *Management Science*, 36, 9, 1120–1132 (1990).

[15] Goetschalckx, M., and Ratliff, H. D., "Optimal Lane Depths for Single and Multiple Products in Block Stacking Storage Systems," *IIE Transactions*, 23, 3, 245–258 (1991).

[16] Hackman, S. T., and Rosenblatt, M. J., "Allocating Items to an Automated Storage and Retrieval System," *IIE Transactions*, 22, 1, 7–14 (1990).

[17] Hall, R. W., "Distance Approximations for Routing Manual Pickers in a Warehouse," *IIE Transactions*, 25, 4, 76–87 (1993).

[18] Hausman, W. H., Schwarz, L. B., and Graves, S. C., "Optimal Storage Assignment in Automated Warehousing Systems," *Management Science*, 22, 6, 625–638 (1976).

[19] Jarvis, J. M., and McDowell, E. D., "Optimal Product Layout in an Order Picking Warehouse," *IIE Transactions*, 23, 1, 93–102 (1991).

[20] Malmborg, C. J., "Storage Assignment Policy Tradeoffs," *International Journal of Production Research*, 34, 2, 363–378 (1996).

[21] Pandit, R., and Palekar, U. S., "Response Time Considerations for Optimal Warehouse Layout Design," *Journal of Engineering for Industry*, 115, 322–328 (1993).

[22] Ratliff, H. D., and Rosenthal, A. S., "Order-Picking in a Rectangular Warehouse: A Solvable Case of the Traveling Salesman Problem," *Operations Research*, 31, 3, 507–521 (1983).

[23] Roll, Y., and Rosenblatt, M. J., "Random Versus Grouped Storage Policies and Their Effect on Warehouse Capacity," *Material Flow*, 1, 199–205 (1983).

[24] Rosenblatt, M. J., and Roll, Y., "Warehouse Design with Storage Policy Considerations," *The International Journal of Production Research*, 22, 5, 809–921 (1984).

[25] Rosenblatt, M. J., and Roll, Y., "Warehouse Capacity in a Stochastic Environment," *The International Journal of Production Research*, 26, 12, 1847–1851 (1988).

[26] Rouwenhorst, B., Reuter, B., Stockrahm, V., van Houtum, G. J., Mantel, R. J., and Zijm, W. H. M., "Warehouse Design and Control: Framework and Literature Review," *European Journal of Operational Research*, 122, 515–533 (2000).

[27] Ruben, R. A., and Jacobs, F. R., "Batch Construction Heuristics and Storage Assignment Strategies for Walk/Ride and Pick Systems," *Management Science*, 45, 4, 575–596 (1999).

[28] Sadiq, M., Landers, T. L., and Taylor, G. D., "An Assignment Algorithm for Dynamic Picking Systems," *IIE Transactions*, 28, 8, 607–616 (1996).

[29] van den Berg, J. P., and Sharp, G. P., "Forward-Reserve Allocation in a Unit-Load Warehouse Operation with Picking Periods," In *Progress in Material Handling Research: 1996*, pp. 625–638. Braun-Brumfield (1996).

[30] van den Berg, J. P., Sharp, G. P., Gademann, A. J. R. M. N., and Pochet, Y., "Forward-Reserve Allocation in a Warehouse with Unit-Load Replenishments," *European Journal of Operational Research*, 111, 98–113 (1998).

Appendix A

Simulation Results for the Initial Hybrid Forward Department

In this appendix we present the results of the 1000 simulation replications for the initial hybrid forward department. The columns labeled "Initial Hybrid NVA" and "Initial Hybrid VA" represent the NVA and VA simulation results for the initial hybrid layout. The columns labeled "+SKU 2 NVA" and "+SKU 2 VA" represent the NVA and VA simulation results for the hybrid layout when SKU 2 is moved to the non-hybrid areas of the forward department. The columns labeled "+SKU 1 NVA" and "+SKU 1 VA" represent the NVA and VA simulation results for the hybrid layout when SKU 1 is moved to the non-hybrid areas of the forward department. The columns labeled "+SKU 3 NVA" and "+SKU 3 VA" represent the NVA and VA simulation results for the hybrid layout when SKU 3 is moved to the non-hybrid areas of the forward department. It should be noted that the hybrid SKUs are presented in order of decreasing turnover ratio (2, 1, 3), which represents the order they are moved out of the hybrid forward area.

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft).

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	93	105	93	105	117	93
93	105	93	81	111	105	105	81
93	105	93	105	93	105	93	39
111	105	93	87	93	114	117	69
93	105	111	114	81	105	117	81
93	105	93	96	111	114	81	81
111	105	93	105	93	81	93	93
93	105	93	81	111	114	93	93
93	81	93	114	81	81	81	93
111	105	111	96	93	81	93	93
99	105	111	96	93	81	93	81
93	81	93	114	111	96	93	81
93	105	81	96	93	105	93	81
93	96	111	81	111	114	81	93
93	96	93	96	93	81	93	93
111	105	93	105	111	105	81	93
111	96	111	81	123	105	117	81
93	96	111	114	93	105	117	81
81	105	93	81	123	81	93	93
93	105	93	96	93	96	93	39
111	96	93	105	93	105	93	81
81	105	93	105	93	96	93	81
111	105	93	81	93	105	117	93
111	105	81	81	93	114	93	93
93	105	99	105	81	114	93	93
93	105	93	96	111	114	93	81
111	96	93	72	111	105	93	93
93	105	99	105	93	33	117	81
93	105	93	105	93	105	117	93
93	81	111	81	93	105	117	93
93	96	93	105	81	96	81	81
93	96	123	87	93	105	93	81
93	96	93	105	111	105	117	81
111	105	81	105	111	96	93	93
93	96	81	105	93	114	117	81
99	96	93	105	111	105	93	81
69	105	93	105	111	96	117	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	93	96	111	72	93	93
93	105	111	105	81	114	81	93
99	105	93	114	81	81	105	81
93	96	111	72	93	105	93	93
93	105	93	105	111	105	93	81
93	105	99	72	111	72	93	93
93	105	93	105	111	105	93	81
81	81	93	96	81	114	93	93
81	81	93	105	111	105	93	81
93	105	93	105	93	105	93	93
81	105	93	81	111	114	93	93
93	105	93	81	93	81	117	81
81	96	111	81	93	105	117	81
93	105	111	114	93	96	93	93
93	105	93	105	93	105	93	93
99	96	81	105	93	81	117	81
111	105	93	81	81	96	81	81
93	105	93	105	93	114	117	81
81	105	111	96	123	81	117	93
93	105	93	105	93	105	117	81
111	105	81	105	81	105	93	81
93	96	93	96	111	72	93	93
123	105	81	114	93	63	93	93
81	96	99	105	93	105	93	93
93	81	81	96	93	105	93	93
123	105	93	72	81	105	129	81
93	81	111	105	123	105	93	93
81	105	93	87	81	72	105	81
93	96	93	96	111	105	105	81
93	105	111	105	93	81	93	81
81	96	93	81	93	105	93	93
93	105	93	105	93	87	117	93
81	105	93	105	81	114	93	93
81	105	93	96	93	81	81	81
81	96	93	105	93	105	129	81
81	96	111	81	93	114	93	93
93	105	111	105	93	105	117	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	93	105	93	114	93	81
93	96	93	105	123	72	93	93
81	105	93	105	93	105	81	93
93	105	111	105	93	114	117	81
99	105	111	81	93	105	117	93
111	81	81	72	81	105	93	81
81	105	93	96	111	105	93	93
111	81	99	72	93	72	117	81
93	105	93	105	81	105	117	81
111	105	93	105	93	105	93	93
93	96	111	63	93	105	93	93
93	105	99	105	93	105	117	81
111	105	93	72	81	105	117	81
81	105	93	96	93	105	93	81
93	96	93	105	93	114	93	93
93	81	93	114	93	72	93	93
123	105	99	105	93	72	117	93
99	105	123	114	93	96	93	81
111	105	93	63	93	105	93	93
111	105	93	114	93	81	105	93
93	96	111	87	111	72	117	81
81	105	93	105	93	105	117	39
111	105	93	105	111	114	93	81
93	105	93	81	93	96	93	81
93	105	93	105	93	105	81	93
93	105	111	105	93	96	81	93
93	105	93	105	93	105	93	93
111	105	93	96	99	105	105	39
93	96	93	96	93	72	105	81
93	105	111	96	93	96	93	93
111	105	93	105	81	114	93	39
111	105	93	72	93	96	93	93
93	105	93	105	93	81	93	93
81	105	81	105	93	96	81	93
93	105	93	105	93	96	93	93
93	96	93	105	93	81	93	93
81	105	81	105	93	105	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	93	105	111	81	93	81
123	96	93	105	93	114	81	93
123	96	93	114	93	96	93	93
123	105	111	81	93	96	93	93
93	105	111	96	93	105	69	93
93	96	93	105	99	96	81	93
111	96	93	96	81	81	93	81
111	105	99	105	81	72	117	93
93	105	93	105	93	105	93	93
93	114	93	81	123	114	93	81
93	105	93	105	111	105	117	93
93	105	93	96	81	105	93	39
93	87	111	81	111	81	117	93
93	72	81	72	93	81	129	81
111	105	111	105	111	105	93	81
81	105	93	105	99	105	117	93
111	114	111	96	93	81	93	81
81	105	111	105	93	105	93	39
93	105	93	114	81	114	117	93
111	105	93	105	93	105	93	93
111	96	111	105	81	105	93	81
123	105	81	105	93	105	93	81
81	105	123	105	93	105	117	81
123	105	93	105	93	96	93	93
93	72	123	96	93	87	117	93
93	96	99	114	93	105	117	93
93	105	93	105	93	105	93	81
81	105	123	72	93	105	117	93
93	96	111	114	111	105	93	93
123	105	99	81	93	114	81	93
81	105	111	114	93	81	93	69
93	105	93	81	93	114	81	93
81	105	93	72	93	105	93	93
93	105	93	105	93	96	117	93
93	87	93	105	93	114	117	93
93	96	93	105	99	105	117	81
93	105	93	81	111	81	105	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
111	81	111	105	93	81	93	93
123	105	93	105	93	105	93	81
81	96	93	96	111	105	93	93
93	105	93	114	93	105	93	93
93	105	111	105	99	105	93	81
93	105	111	105	111	81	117	93
93	96	81	81	111	105	81	81
93	105	93	72	93	105	93	93
93	105	111	105	93	96	117	93
111	105	123	96	93	105	129	81
93	105	93	114	93	105	93	81
81	81	111	114	93	81	93	93
111	96	111	96	93	105	69	81
93	105	111	81	81	96	117	81
111	96	93	105	123	105	93	81
111	105	111	96	111	105	93	93
93	96	99	81	111	96	93	93
111	105	81	114	93	105	81	93
99	105	93	81	111	105	93	81
93	105	93	72	81	105	129	93
99	105	111	105	93	96	93	81
93	105	111	96	93	96	93	81
123	105	93	105	93	105	93	93
93	105	93	81	93	105	81	93
93	96	93	72	93	81	93	81
93	105	93	105	93	72	117	93
93	87	81	72	93	96	105	93
99	81	123	81	93	105	93	81
93	96	93	72	111	105	117	93
93	96	81	114	93	96	93	81
81	105	93	96	93	114	105	93
123	105	81	81	123	105	93	81
111	105	93	105	93	105	117	93
93	105	93	114	93	96	93	93
81	105	111	96	93	96	93	93
93	105	99	105	93	96	117	81
81	81	93	81	81	96	117	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
81	105	93	96	93	105	81	81
93	105	93	105	93	105	39	93
81	72	93	105	93	96	93	93
93	105	111	105	111	105	93	81
111	105	123	105	123	105	93	93
93	105	93	96	93	72	93	81
111	96	93	105	93	105	117	81
93	96	93	72	111	105	93	93
111	105	111	114	111	105	93	81
93	114	93	81	111	105	93	81
111	105	81	105	93	105	93	81
93	105	111	105	111	96	117	93
99	105	93	96	93	105	93	93
111	96	93	114	93	105	117	93
93	96	93	105	99	105	93	81
81	105	111	96	111	105	93	81
93	96	93	105	93	105	117	93
99	105	93	81	93	96	93	81
111	105	93	114	111	96	117	93
93	105	93	96	93	81	81	93
93	105	93	72	93	105	117	81
93	105	81	105	111	105	93	81
93	105	93	114	93	105	93	93
93	105	111	96	93	105	81	93
111	105	93	72	93	114	117	81
93	105	93	114	93	72	117	81
111	105	111	72	93	105	117	93
99	105	93	81	93	105	93	93
93	105	81	81	81	105	117	93
93	105	93	96	93	105	117	93
111	105	81	105	93	81	93	81
93	96	93	72	93	105	93	81
111	105	111	96	93	105	117	93
93	105	111	105	111	96	117	81
93	96	123	72	81	96	117	93
111	96	111	96	93	96	81	93
111	105	93	105	93	105	81	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
123	96	93	105	93	81	81	69
111	105	93	105	93	105	93	93
93	96	111	105	93	105	117	93
93	105	93	81	81	96	117	39
123	105	93	105	123	105	93	93
93	105	93	105	93	105	93	93
81	105	111	96	99	96	129	93
69	105	93	114	93	105	117	93
93	105	81	105	123	105	93	93
93	105	93	105	93	96	93	93
81	96	93	105	93	114	105	93
93	105	81	81	93	105	105	81
111	105	93	96	111	105	117	93
81	105	99	72	81	96	81	81
99	96	93	114	93	96	93	81
93	105	111	72	81	96	93	93
93	105	93	105	81	114	81	81
93	105	81	114	93	72	93	93
123	105	39	96	111	105	117	93
93	105	93	81	93	105	117	93
93	105	93	114	93	114	117	93
111	105	123	81	81	105	81	93
111	105	93	81	93	33	93	93
81	105	93	105	111	105	105	93
81	72	93	105	111	114	39	27
111	105	93	96	81	114	93	93
93	105	123	114	93	105	93	93
81	96	93	96	111	105	117	93
123	105	111	96	93	96	93	81
93	96	93	114	93	96	117	81
93	96	93	81	93	105	81	81
93	105	93	105	111	72	93	39
111	105	81	105	93	105	81	93
81	96	93	105	93	105	129	93
111	105	81	72	81	105	93	81
111	96	99	105	93	105	93	93
93	105	111	96	93	96	93	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	111	105	93	105	93	93
111	105	81	105	81	72	93	93
111	105	111	81	93	105	117	81
93	105	111	81	93	105	93	93
111	105	93	96	93	81	81	93
93	96	93	114	93	105	93	81
111	105	93	105	111	105	117	93
111	105	99	114	111	114	81	81
93	81	93	87	111	114	93	27
111	96	81	105	93	105	117	93
93	105	93	105	81	105	117	93
93	105	81	105	93	96	93	93
81	96	111	96	93	96	93	93
93	105	69	81	81	105	93	93
93	105	111	105	93	105	105	81
69	96	93	105	93	105	93	81
111	96	93	105	81	96	39	93
93	105	99	105	93	96	117	81
111	105	111	105	93	96	93	93
93	105	111	114	111	81	81	81
93	105	93	96	111	114	93	81
93	105	93	105	111	114	93	93
93	96	93	105	93	105	93	81
93	105	111	105	111	81	93	93
123	105	111	81	93	96	93	93
93	81	111	114	93	96	93	93
93	81	93	105	93	81	93	39
111	96	111	105	93	96	129	93
93	114	93	105	93	96	117	81
111	105	81	105	93	105	93	81
111	105	93	72	93	114	93	93
87	105	81	96	93	105	93	93
93	81	93	105	111	105	81	93
93	105	93	105	93	105	93	81
93	96	39	72	81	96	93	81
111	96	111	72	111	105	105	81
81	96	111	105	93	114	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	93	105	99	81	117	81
93	105	93	81	93	72	81	39
111	105	93	72	111	105	93	81
93	96	93	114	81	114	93	39
93	105	111	72	93	105	81	93
111	105	93	105	111	105	81	93
111	96	81	96	111	81	81	81
123	105	81	105	93	96	93	93
93	105	93	114	93	105	93	93
111	96	93	72	111	81	93	93
93	105	93	105	81	105	93	93
93	105	99	96	93	96	93	81
93	96	93	105	93	72	93	93
111	81	93	96	93	72	93	81
111	96	39	105	93	114	81	81
111	81	111	81	93	105	93	81
93	96	123	105	81	105	93	93
93	105	93	72	93	96	93	93
111	96	81	105	93	105	93	81
111	105	93	96	99	105	117	81
93	105	111	105	93	96	93	93
93	87	111	105	93	114	117	93
93	105	93	114	93	72	117	93
81	105	93	81	93	105	93	93
111	105	81	105	111	96	93	93
81	105	81	105	93	96	93	93
111	96	111	96	99	105	93	93
93	105	111	105	111	114	93	81
93	81	93	81	81	105	93	93
93	105	81	105	81	96	117	81
93	96	93	81	93	114	81	93
93	96	93	105	81	81	93	93
93	114	93	96	111	105	117	81
93	105	81	105	93	105	117	81
81	96	93	114	111	96	129	93
93	96	81	105	81	105	81	93
93	96	93	105	93	96	117	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	111	105	93	105	93	93
93	105	93	105	93	105	93	81
111	81	99	105	93	81	93	93
111	105	93	105	93	105	81	81
93	72	111	72	93	105	93	93
93	96	111	81	93	105	117	93
93	105	93	96	123	105	93	93
93	96	123	105	123	114	117	93
81	81	93	114	93	72	93	93
93	96	39	105	111	63	81	93
111	96	123	105	93	114	81	69
93	105	81	105	93	105	117	69
81	96	81	72	93	81	93	81
93	81	111	96	81	105	93	93
111	105	93	105	93	81	105	93
93	105	93	81	111	96	93	81
93	105	123	105	93	105	93	93
111	105	93	81	93	72	117	93
93	81	81	114	111	81	93	81
93	105	93	96	93	114	93	93
81	105	93	81	123	114	93	93
111	105	111	105	99	105	93	93
81	105	99	105	93	81	93	39
93	105	81	105	81	114	93	81
93	105	93	81	81	114	81	93
81	105	93	114	93	105	93	93
93	105	93	72	111	81	93	81
81	105	81	96	81	96	105	93
93	105	93	105	111	105	93	81
93	96	81	96	93	105	93	93
93	96	93	114	93	72	93	81
93	105	111	105	93	81	93	93
111	105	93	72	81	114	93	39
111	96	93	96	81	81	117	81
93	105	81	105	81	105	93	93
93	105	93	96	81	96	81	81
111	105	111	81	93	96	81	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	81	81	105	93	81	117	93
99	96	123	114	99	114	93	93
123	105	81	96	93	96	93	93
93	105	93	105	93	105	93	81
93	105	111	105	111	105	93	93
81	105	93	105	93	96	117	93
111	105	93	105	93	105	81	93
93	96	81	105	81	81	117	81
93	105	123	105	123	105	93	81
93	96	93	105	93	96	93	93
93	105	93	96	93	114	117	93
111	105	99	96	111	96	117	93
111	105	81	96	111	72	117	81
111	96	93	81	111	114	93	93
111	105	111	72	81	105	117	93
93	105	123	105	93	105	93	81
93	105	93	105	93	81	93	81
93	105	111	81	111	114	117	93
111	105	93	105	111	81	117	93
93	105	111	81	111	96	117	81
93	105	93	96	111	114	93	93
99	105	93	105	93	114	81	93
93	96	93	105	93	63	117	39
93	96	123	96	81	105	93	81
93	105	111	81	93	105	81	93
93	96	81	105	93	105	117	81
93	105	93	105	93	105	93	81
93	105	111	105	81	105	117	93
93	105	111	105	123	114	93	93
93	105	93	72	111	114	117	81
93	105	111	96	93	105	117	81
81	81	93	96	111	105	93	93
93	105	93	105	93	96	117	81
111	105	93	105	111	96	81	81
93	105	93	87	93	105	93	39
111	96	93	105	93	96	105	39
81	96	99	114	93	105	69	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	81	114	111	105	93	93
93	81	93	81	99	114	93	93
93	72	81	96	39	81	93	81
93	87	93	96	93	114	93	93
93	105	93	105	93	114	129	93
111	105	93	105	93	105	93	93
99	105	111	105	111	105	117	93
93	81	93	105	99	114	93	69
93	96	93	96	93	114	93	93
111	87	123	72	93	96	93	81
93	87	93	105	99	72	93	93
81	105	93	105	93	114	81	93
93	96	39	63	111	81	93	81
123	105	99	105	81	105	93	81
93	105	93	105	93	105	93	93
93	105	93	105	111	105	117	93
81	105	111	105	99	105	117	81
93	96	111	81	93	105	93	93
93	81	123	81	93	114	93	93
93	105	93	114	93	105	93	81
123	105	93	105	93	96	93	81
93	105	93	105	93	96	93	93
81	105	111	105	93	105	81	93
81	105	93	96	123	105	93	81
111	96	99	105	81	72	93	81
81	105	99	105	93	81	81	81
93	81	99	72	93	96	81	93
93	81	81	105	93	105	93	93
123	96	81	96	93	105	81	81
111	105	93	96	93	105	93	81
81	114	93	72	81	96	81	93
99	105	111	105	123	105	93	81
93	96	111	105	93	114	93	81
93	105	93	105	111	105	129	93
111	105	81	114	81	114	81	81
93	81	93	105	93	105	117	81
81	105	99	114	111	81	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
111	105	93	114	99	81	93	81
111	105	111	105	93	105	117	93
93	105	111	96	93	105	93	81
93	81	93	105	93	105	93	93
81	96	81	105	93	105	105	93
93	105	111	105	93	114	93	81
93	96	111	96	93	105	93	93
93	96	111	105	123	114	93	81
111	105	93	96	81	96	117	93
93	105	111	81	93	105	117	81
93	81	81	114	93	114	81	93
93	105	93	114	93	105	93	69
81	105	93	96	93	105	93	69
111	105	93	114	81	105	117	93
93	105	81	114	111	81	117	81
111	105	93	105	93	105	93	93
93	105	93	105	93	105	93	93
93	105	93	81	93	114	117	93
93	105	81	72	93	105	93	93
93	105	111	105	111	114	117	93
111	105	111	105	111	72	93	93
111	105	111	114	93	105	93	93
81	105	81	105	93	72	117	93
111	105	93	96	93	81	93	81
93	105	111	105	93	105	93	93
81	81	81	96	93	105	93	93
93	81	81	87	93	114	93	81
123	105	111	105	93	96	93	93
93	96	111	105	93	105	93	39
93	105	111	105	81	105	93	93
81	105	111	81	81	72	81	93
111	96	93	105	93	72	93	81
93	105	111	96	111	105	117	81
93	105	93	105	93	105	93	81
111	81	93	105	93	105	105	93
93	96	111	105	93	105	117	93
123	105	111	105	81	105	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
111	105	111	105	93	96	93	81
81	72	81	105	93	105	93	93
93	105	123	114	99	105	117	93
81	114	93	96	111	96	93	93
93	105	93	72	93	105	93	93
93	105	111	81	93	105	93	81
93	96	93	105	93	105	93	81
93	105	93	114	93	105	93	93
81	105	81	114	81	72	93	93
93	96	93	114	93	96	93	93
93	105	93	105	81	105	117	93
123	105	93	33	111	81	117	93
123	96	93	81	93	81	93	93
93	105	111	105	93	96	93	81
93	81	93	105	93	96	93	93
93	105	93	105	111	105	129	93
81	105	69	81	111	96	81	93
93	105	123	105	93	96	93	81
81	105	93	81	111	81	93	93
99	96	123	105	81	105	93	93
111	96	93	114	111	72	93	93
93	96	111	105	81	105	93	81
123	96	93	105	93	96	117	81
93	96	93	72	93	114	93	81
93	105	123	105	123	105	39	81
93	105	93	72	111	81	117	81
81	96	81	105	69	105	117	93
93	105	111	105	93	105	81	93
111	105	81	105	93	105	93	93
111	105	93	81	93	105	93	93
81	105	111	105	111	105	81	93
93	105	111	96	81	105	129	81
93	105	111	105	111	105	93	93
93	105	93	72	93	72	81	81
93	96	93	114	93	72	93	39
93	105	93	72	81	72	117	81
93	96	93	96	81	105	81	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
111	105	93	105	93	105	93	81
93	105	93	105	123	81	93	93
93	96	81	105	93	96	39	81
81	105	81	81	93	105	93	93
93	105	93	72	93	105	117	39
93	81	93	105	81	105	81	81
93	105	93	105	93	114	93	93
93	105	93	72	93	96	117	81
93	105	93	72	81	96	81	93
93	105	93	105	111	105	117	93
111	96	93	81	111	87	117	81
93	105	81	105	93	96	117	93
93	105	81	96	93	105	93	93
111	96	93	105	111	105	117	69
81	105	93	114	93	105	93	93
93	81	111	105	93	105	105	81
93	105	93	96	123	72	93	81
93	72	111	81	123	96	81	93
93	72	93	105	93	105	93	93
93	105	111	96	111	105	81	81
93	105	93	114	93	81	81	93
93	105	111	81	93	105	93	93
111	81	111	105	111	105	117	93
111	105	93	105	111	105	93	93
93	96	111	114	93	81	93	93
93	105	111	105	93	105	117	93
93	105	81	105	93	96	117	81
81	96	111	81	93	72	93	93
123	105	93	105	93	96	117	81
81	105	93	105	93	105	93	81
99	96	93	105	93	105	93	93
123	105	111	105	93	105	93	93
99	105	93	72	93	105	93	81
93	96	93	96	81	114	93	93
123	105	93	105	99	96	93	93
93	96	93	96	81	105	81	93
93	105	111	105	93	114	81	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	81	105	93	105	93	81
93	105	93	81	93	105	129	93
81	105	93	96	93	105	129	81
111	105	93	105	123	105	93	81
93	72	93	81	93	114	93	93
111	96	93	105	93	105	129	81
99	105	93	96	81	105	93	81
99	87	81	105	93	114	93	93
81	87	93	96	93	96	81	81
93	96	93	96	93	81	93	81
81	105	93	105	93	72	81	93
111	105	81	114	81	105	117	81
123	72	81	105	111	105	93	93
93	96	93	105	93	114	93	93
111	105	111	105	111	105	117	81
111	105	111	105	93	105	93	93
93	105	111	96	123	105	81	93
111	105	93	105	93	96	117	93
99	105	93	81	93	72	93	81
111	105	99	105	93	105	93	93
93	96	81	105	123	114	117	93
93	81	111	105	93	96	117	39
93	72	123	105	93	105	93	93
111	105	99	114	93	105	93	93
93	105	93	105	93	114	93	81
123	105	93	81	123	105	93	93
111	105	111	96	93	105	93	93
111	105	93	105	123	105	93	81
111	105	111	114	81	96	93	93
93	105	93	96	93	105	93	81
93	96	99	105	111	81	93	93
111	96	93	105	93	114	93	93
81	105	93	105	81	105	93	81
123	105	93	105	111	114	117	93
111	105	111	105	93	105	117	93
93	87	111	105	93	105	93	81
93	105	93	81	111	114	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	111	81	93	96	117	93
111	96	99	105	93	96	117	93
93	105	93	87	93	105	93	81
81	105	93	81	93	105	117	93
93	96	81	105	93	72	117	93
111	96	93	105	123	105	117	93
111	105	93	96	111	105	81	93
93	96	81	87	81	105	93	81
93	96	93	105	93	105	93	93
93	105	81	81	93	114	93	93
81	105	99	105	111	105	93	93
93	105	111	96	93	81	117	81
99	96	39	87	93	105	117	93
93	96	93	96	93	114	117	93
81	105	93	105	93	96	93	81
111	105	93	105	93	81	93	93
111	105	93	105	81	105	93	81
93	105	99	72	69	96	93	93
93	96	123	114	81	105	93	81
69	105	111	87	93	105	81	81
111	105	93	87	93	105	81	93
93	105	93	114	93	114	93	81
93	105	111	105	81	105	93	81
93	105	93	105	93	105	93	93
93	96	81	33	93	105	93	93
111	96	111	105	111	96	81	93
93	105	93	81	111	105	117	81
111	105	93	96	111	114	117	93
93	81	99	105	111	105	117	93
99	105	93	96	93	33	117	93
93	96	99	96	111	105	93	93
93	105	111	96	93	72	93	81
93	105	93	96	93	105	93	81
123	105	111	105	93	114	93	93
93	105	111	105	81	105	93	93
93	96	99	105	111	105	93	81
93	105	123	96	93	114	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	81	99	81	111	81	117	93
93	105	93	105	99	105	93	93
93	105	111	96	99	114	93	93
93	105	93	96	93	105	81	93
81	105	93	105	111	81	129	93
111	105	93	72	123	105	93	81
111	105	93	96	111	105	81	93
93	105	93	81	93	72	117	93
81	105	81	96	111	81	93	93
93	105	93	72	93	105	105	81
81	105	93	114	93	96	81	93
123	105	93	105	123	105	93	81
93	105	93	96	93	105	93	81
111	105	93	105	99	114	93	93
93	105	93	105	93	81	93	81
111	105	93	96	93	114	81	81
93	105	81	105	93	105	93	39
111	105	93	105	111	96	93	93
93	105	93	105	111	114	117	81
81	81	111	96	93	96	81	93
93	105	81	114	93	105	93	93
111	105	93	105	81	72	117	93
99	105	111	105	123	105	93	81
93	105	93	96	93	105	105	93
93	96	123	33	93	105	93	93
93	81	93	105	93	105	93	93
111	105	93	105	81	105	81	81
93	105	111	105	81	105	93	93
93	105	93	105	93	105	117	93
93	114	93	105	81	96	93	93
93	96	81	105	93	96	93	93
93	96	111	105	111	63	81	93
111	96	93	105	93	96	93	93
123	96	93	105	93	105	81	81
93	105	111	96	93	114	93	93
93	96	123	105	93	114	81	93
111	105	93	105	81	96	93	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	81	72	111	105	105	93
93	114	81	114	93	105	93	93
93	96	93	96	93	72	117	93
93	105	81	105	93	114	93	81
93	105	81	105	93	105	93	81
81	105	93	114	111	81	81	81
93	105	99	105	93	96	129	93
93	96	111	96	93	105	93	93
93	96	93	105	93	81	93	81
93	105	93	105	123	72	117	93
93	96	111	105	93	105	117	81
69	81	111	72	81	105	117	93
81	105	93	105	123	81	117	81
81	96	93	105	81	81	117	81
93	105	93	114	93	87	93	81
111	105	93	105	81	96	93	81
81	96	111	72	93	105	117	93
111	105	93	105	93	81	81	81
93	81	93	96	93	105	105	93
93	87	81	105	111	105	129	93
93	96	111	105	93	105	93	93
123	96	93	96	39	105	93	93
93	72	81	105	93	96	117	81
93	105	93	105	93	81	93	93
93	105	93	105	123	81	93	81
81	105	93	105	111	96	117	93
93	105	81	96	93	105	93	81
93	105	111	81	111	114	117	93
111	96	93	105	93	114	93	93
81	105	93	105	111	96	93	93
111	96	111	105	93	105	93	93
81	105	111	87	93	114	81	93
93	81	81	105	93	81	93	93
93	105	93	105	99	105	81	93
81	105	93	114	93	105	93	81
111	81	93	96	93	96	117	81
93	96	111	114	93	114	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	93	105	93	105	81	81
111	105	93	105	111	114	81	81
93	87	93	96	93	96	93	81
99	96	93	81	93	105	93	93
93	105	111	96	93	96	93	93
81	105	81	96	111	105	129	81
93	105	93	105	93	105	117	93
123	105	93	96	81	96	81	81
81	105	39	105	93	72	93	93
93	105	111	105	111	105	93	93
111	105	111	81	93	81	93	93
111	96	93	105	93	105	93	93
111	105	93	114	81	105	117	93
111	96	111	105	81	105	93	81
93	96	81	105	81	96	93	81
93	105	99	105	111	105	93	93
111	105	81	96	93	105	117	93
81	105	81	105	111	114	93	93
111	105	93	81	111	105	117	93
93	96	81	96	111	105	117	93
111	105	93	72	111	105	81	93
93	105	93	105	99	81	117	93
93	96	111	96	81	105	81	81
111	105	111	105	111	105	117	39
111	105	111	114	111	114	93	93
111	105	93	105	111	81	93	93
93	105	93	114	93	105	117	81
93	105	111	96	93	105	105	81
81	105	93	72	81	105	93	93
81	105	111	105	93	105	117	81
93	81	93	96	81	81	93	93
93	105	93	105	81	81	93	93
93	105	93	105	111	105	117	93
111	96	93	105	93	105	93	81
111	105	93	105	81	105	93	81
123	105	93	72	93	72	117	93
93	105	123	96	123	114	81	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	81	96	99	114	93	81
111	114	111	105	111	105	117	93
111	105	93	105	99	81	81	93
111	105	111	96	93	96	81	81
93	105	81	105	93	105	81	81
93	105	81	105	93	105	93	93
81	114	93	105	111	96	93	93
111	105	81	105	93	72	93	81
93	105	93	72	81	114	93	93
93	105	93	105	81	114	93	93
81	114	93	96	111	105	105	81
93	105	111	96	93	114	117	93
93	96	111	105	93	105	93	81
93	105	93	96	81	81	81	81
93	105	81	96	111	96	93	93
93	105	123	105	93	105	93	93
93	105	93	105	93	96	81	93
93	105	111	96	93	114	81	93
93	105	93	72	111	105	93	81
81	96	111	105	111	105	93	93
93	105	93	105	93	96	117	81
81	96	93	81	93	105	93	93
123	105	93	105	81	81	117	93
123	105	93	105	81	114	105	81
93	105	93	105	93	105	93	93
93	105	93	105	81	105	93	93
93	105	81	81	81	72	81	81
93	105	81	72	111	105	93	81
93	105	81	81	93	105	93	93
111	105	111	105	93	105	39	93
111	105	111	72	93	105	93	93
111	105	93	105	93	105	117	93
93	105	111	63	93	105	117	81
111	96	93	105	93	96	81	81
81	96	111	72	93	81	117	81
111	105	111	81	123	72	117	81
93	105	93	105	93	105	93	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	111	96	93	105	93	93
93	96	81	72	93	105	93	81
93	105	93	105	81	105	105	93
111	81	93	114	111	105	93	81
93	96	93	105	93	105	93	81
93	81	93	81	111	105	117	81
123	105	93	105	93	96	93	39
69	105	93	96	81	81	81	81
81	96	93	96	93	96	117	93
93	81	81	81	93	105	93	93
93	105	93	105	93	81	105	93
93	105	111	96	93	105	105	81
93	87	111	105	123	114	93	81
93	105	93	81	81	96	117	93
93	72	93	87	81	105	93	93
93	105	111	105	93	105	93	93
93	105	111	105	93	105	117	93
81	105	111	81	111	81	93	93
93	105	93	96	81	105	117	39
93	105	81	81	93	81	93	93
93	105	99	105	111	72	93	93
81	105	93	96	93	105	105	93
93	96	81	105	93	105	117	81
111	105	111	114	93	105	93	93
93	105	93	105	111	105	117	93
93	105	81	114	93	96	105	93
93	105	111	114	111	96	93	93
81	105	93	81	81	105	117	69
111	105	99	105	93	105	93	93
99	105	81	105	111	72	117	93
93	105	93	81	93	105	105	93
93	87	111	105	111	105	93	93
81	105	111	96	99	105	117	81
111	105	111	96	93	96	81	81
81	105	111	96	123	105	93	93
93	105	93	96	111	96	117	81
93	105	93	105	93	105	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
111	105	111	96	81	114	93	93
111	96	69	96	111	114	117	93
93	105	81	105	93	105	93	93
111	105	93	96	111	96	105	93
81	105	93	114	81	105	117	81
111	96	111	105	93	105	117	81
93	105	111	105	93	81	129	93
81	105	39	96	93	105	117	93
93	105	111	96	81	96	93	93
93	96	93	81	93	105	93	93
93	105	111	114	111	114	81	93
111	105	81	114	123	81	93	81
111	105	111	96	93	81	69	81
111	105	111	96	93	114	93	81
81	105	93	114	111	114	129	81
111	96	111	105	111	96	81	81
93	96	99	96	81	81	93	81
93	105	81	105	93	105	93	81
93	72	93	96	81	81	93	93
93	105	93	105	93	114	93	93
81	105	123	72	123	114	117	93
81	96	93	96	81	105	105	93
111	96	111	96	81	87	81	93
93	105	93	105	111	105	93	93
81	105	123	96	93	72	93	93
93	96	111	105	93	105	117	93
111	81	93	96	111	96	117	93
93	105	111	105	81	105	93	81
81	96	93	114	111	105	117	81
111	105	81	81	81	105	105	81
93	96	93	81	93	114	93	93
81	105	93	96	111	81	117	81
93	105	81	105	93	105	93	93
111	105	81	105	93	96	93	81
111	105	93	81	123	72	81	93
93	81	93	81	93	105	117	69
81	81	111	105	111	114	93	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
81	96	111	105	81	105	93	93
93	105	81	87	111	114	93	93
93	105	111	105	111	105	93	81
93	105	81	81	111	105	93	93
81	72	93	72	111	81	117	93
69	105	93	105	81	81	93	93
111	96	93	114	93	105	129	81
93	105	93	81	93	114	117	93
111	105	93	105	93	105	93	93
111	105	123	72	111	81	81	93
93	96	93	96	93	105	117	93
93	105	81	105	93	105	93	81
93	105	93	114	93	96	129	93
111	105	81	105	93	105	81	93
111	81	93	105	81	96	93	93
93	105	93	105	93	105	93	81
111	72	93	105	111	72	117	93
81	96	93	81	93	96	93	93
111	105	93	96	111	96	93	81
93	105	81	72	111	105	93	81
81	105	93	105	93	96	81	93
81	105	93	114	81	72	93	93
93	72	93	81	111	81	93	93
93	105	81	105	93	105	81	81
93	96	111	105	93	114	117	93
81	105	93	105	93	96	93	69
93	96	99	81	99	96	117	93
111	96	81	105	111	105	129	93
93	96	93	105	123	105	69	93
123	105	111	105	111	114	93	93
93	105	111	114	81	114	81	93
93	105	81	105	111	105	93	93
93	96	81	105	93	105	93	93
81	96	123	105	111	96	129	81
93	105	111	105	111	105	93	93
81	105	99	105	93	105	117	93
99	105	111	114	93	96	93	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	96	111	105	93	105	105	93
93	96	93	81	123	24	93	81
93	105	81	105	81	81	81	93
93	72	81	114	93	105	93	81
111	105	111	81	81	105	93	81
93	105	81	105	123	105	93	93
93	105	93	96	93	96	117	93
81	105	93	105	111	114	93	81
93	105	93	105	111	105	117	81
111	105	93	105	93	105	117	69
81	105	111	105	93	114	81	93
111	105	93	105	81	87	129	81
111	105	111	105	93	105	93	93
93	96	93	105	81	105	117	81
111	72	93	81	111	81	117	81
93	96	111	105	123	72	93	81
111	96	93	105	81	114	93	93
93	105	93	114	81	105	117	93
93	72	93	105	93	114	93	93
111	81	111	105	81	105	93	93
111	105	81	81	93	96	81	93
93	87	93	105	93	96	93	93
93	96	81	96	111	105	93	93
93	105	99	105	93	105	117	93
93	105	93	72	81	105	93	93
111	105	81	81	93	87	117	93
93	105	93	105	81	105	93	81
93	96	93	72	93	105	93	93
93	105	93	81	81	105	93	93
93	96	93	105	93	114	93	81
93	105	93	81	111	81	117	81
81	105	111	72	93	81	117	93
93	96	111	72	81	105	39	93
81	105	111	105	93	114	93	69
93	96	99	96	99	105	81	81
123	96	81	114	99	105	93	93
93	96	81	105	93	114	69	81

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
81	105	123	72	99	96	93	81
93	96	99	105	93	114	81	93
93	105	93	81	111	105	81	93
81	96	93	105	93	105	93	93
111	105	93	96	111	114	93	81
111	96	111	105	111	96	117	93
93	105	111	96	81	81	81	93
69	105	111	96	111	81	117	81
93	81	93	105	93	96	93	93
81	105	111	81	93	105	93	81
93	96	111	105	111	105	93	93
123	105	111	114	93	105	117	81
93	105	93	114	81	105	81	81
111	96	81	114	93	105	129	93
93	105	111	72	93	105	81	81
93	105	93	105	81	105	81	93
93	114	99	96	111	114	105	93
93	105	111	105	99	96	129	93
123	105	81	114	81	105	81	93
111	105	99	105	93	105	81	93
93	105	93	105	93	105	117	93
111	81	93	105	111	72	81	93
93	105	93	81	93	105	93	93
93	105	93	105	93	105	93	93
111	105	81	114	111	96	129	81
81	105	93	105	93	72	93	93
93	81	93	96	93	105	93	93
93	81	93	96	93	72	81	93
99	87	111	96	93	105	117	93
93	105	93	114	81	105	93	93
81	81	93	114	111	105	93	93
93	105	93	105	93	87	93	81
111	105	111	81	93	72	105	93
93	105	111	105	93	105	117	81
81	105	111	105	93	96	81	93
93	105	93	96	81	105	117	81
93	96	81	105	111	105	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
93	105	93	105	39	105	93	81
111	87	81	96	93	105	81	81
93	105	81	105	93	96	117	93
93	105	81	105	81	105	117	93
93	105	99	105	93	105	93	81
93	81	111	96	111	105	93	81
111	105	123	72	93	105	93	81
81	96	81	105	123	105	117	93
93	105	111	105	93	105	93	93
81	114	93	114	111	114	105	93
81	105	123	105	81	96	81	81
81	105	111	96	99	105	117	93
93	81	93	105	111	105	117	93
81	105	93	72	111	105	93	93
93	96	81	81	93	81	81	93
93	96	93	81	93	114	93	93
111	96	93	105	93	105	117	93
93	96	111	63	93	105	93	93
93	105	93	72	93	105	93	81
93	105	93	81	93	96	93	93
93	81	93	114	81	114	117	93
93	105	93	105	93	96	105	93
81	105	81	105	93	96	93	93
111	72	111	105	111	63	93	93
81	105	93	114	93	105	117	93
111	105	93	105	93	96	117	93
93	105	93	81	93	105	93	93
93	105	111	114	93	81	81	93
111	105	93	81	81	105	93	81
93	105	93	96	81	114	117	81
123	105	93	72	93	96	93	81
111	105	81	105	99	96	117	93
93	105	93	105	93	96	129	81
111	96	111	114	93	114	117	93
111	105	123	81	111	105	93	81
93	96	93	96	93	87	81	93
93	105	111	105	93	105	93	93

Table A.1: Simulation Results for the Initial Hybrid Forward Department (ft) *(continued).*

Initial Hybrid		**+SKU 2**		**+SKU 1**		**+SKU 3**	
NVA	**VA**	**NVA**	**VA**	**NVA**	**VA**	**NVA**	**VA**
81	105	93	105	81	105	93	93

Appendix B

Cross Creek Example Data – Combined

In this appendix we present the combined data for the Cross Creek example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Ave. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table B.1: Cross Creek Example Data – Combined.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
1	21	21.1	20.0	7.0	19.0	32.0	36.0	50.0	4.0	1.0	NVA
2	21	6.9	2.0	11.0	8.0	11.0	8.0	3.0	8.0	4.0	NVA
3	21	27.3	32.0	40.0	3.0	42.0	0.0	29.0	41.0	31.0	NVA
4	21	5.6	5.0	3.0	7.0	8.0	6.0	6.0	7.0	3.0	HY
5	21	20.0	17.0	19.0	23.0	21.0	18.0	9.0	29.0	24.0	HY
6	21	4.6	5.0	4.0	7.0	5.0	3.0	2.0	6.0	5.0	NVA
7	21	16.8	25.0	28.0	29.0	8.0	3.0	2.0	25.0	14.0	NVA
8	21	8.0	8.0	4.0	12.0	1.0	7.0	10.0	11.0	11.0	NVA
9	21	15.5	2.0	7.0	29.0	18.0	10.0	6.0	26.0	26.0	NVA
10	21	4.1	4.0	7.0	4.0	3.0	3.0	2.0	6.0	4.0	NVA
11	21	2.4	0.0	0.0	4.0	4.0	1.0	4.0	3.0	3.0	NVA
12	22	4.9	5.0	8.0	5.0	10.0	2.0	2.0	5.0	2.0	NVA
13	22	20.0	14.0	8.0	19.0	23.0	11.0	31.0	25.0	29.0	HY
14	22	7.0	13.0	10.0	13.0	2.0	4.0	8.0	5.0	1.0	NVA
15	22	5.3	2.0	9.0	4.0	4.0	10.0	7.0	0.0	6.0	NVA
16	22	29.8	34.0	45.0	40.0	17.0	16.0	34.0	40.0	12.0	NVA

Table B.1: Cross Creek Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
17	22	17.8	4.0	26.0	32.0	1.0	26.0	2.0	26.0	25.0	NVA
18	22	3.9	5.0	6.0	6.0	4.0	2.0	3.0	4.0	1.0	NVA
19	22	34.8	47.0	36.0	34.0	44.0	29.0	20.0	47.0	21.0	NVA
20	22	4.4	0.0	1.0	7.0	5.0	8.0	8.0	4.0	2.0	HY
21	22	10.0	14.0	12.0	6.0	6.0	11.0	4.0	7.0	20.0	NVA
22	22	29.8	9.0	11.0	44.0	32.0	41.0	28.0	35.0	38.0	NVA
23	22	9.9	15.0	2.0	11.0	5.0	14.0	1.0	23.0	8.0	HY
24	22	26.3	45.0	17.0	51.0	2.0	32.0	45.0	16.0	2.0	HY
25	22	16.0	15.0	20.0	0.0	9.0	17.0	26.0	26.0	15.0	HY
26	23	12.5	15.0	3.0	20.0	6.0	10.0	12.0	22.0	12.0	NVA
27	23	31.9	51.0	15.0	37.0	44.0	14.0	45.0	30.0	19.0	HY
28	23	4.6	6.0	1.0	3.0	4.0	8.0	6.0	2.0	7.0	HY
29	23	12.5	14.0	17.0	6.0	17.0	17.0	15.0	12.0	2.0	NVA
30	23	2.8	3.0	1.0	3.0	3.0	5.0	5.0	2.0	0.0	NVA
31	23	28.1	20.0	21.0	31.0	0.0	25.0	43.0	50.0	35.0	NVA
32	23	31.0	48.0	54.0	42.0	6.0	21.0	14.0	26.0	37.0	HY
33	23	21.9	6.0	17.0	8.0	4.0	1.0	47.0	49.0	43.0	HY
34	23	3.3	5.0	2.0	5.0	1.0	3.0	2.0	4.0	4.0	NVA
35	23	9.8	21.0	4.0	6.0	12.0	4.0	2.0	18.0	11.0	NVA
36	23	2.8	5.0	4.0	4.0	2.0	1.0	1.0	3.0	2.0	NVA
37	23	13.1	18.0	2.0	6.0	2.0	6.0	48.0	6.0	17.0	NVA
38	23	20.6	39.0	5.0	1.0	5.0	33.0	29.0	44.0	9.0	NVA
39	23	27.5	33.0	0.0	16.0	47.0	26.0	27.0	19.0	52.0	HY
40	24	3.0	4.0	4.0	5.0	1.0	2.0	1.0	4.0	3.0	NVA
41	24	26.0	35.0	32.0	32.0	22.0	15.0	30.0	26.0	16.0	NVA
42	24	22.0	35.0	27.0	26.0	0.0	40.0	30.0	16.0	2.0	HY
43	24	15.3	19.0	38.0	15.0	8.0	3.0	18.0	4.0	17.0	NVA
44	24	38.0	25.0	47.0	41.0	9.0	51.0	58.0	19.0	54.0	NVA
45	24	3.4	1.0	2.0	3.0	6.0	3.0	3.0	3.0	6.0	NVA
46	24	26.3	27.0	14.0	32.0	12.0	36.0	24.0	30.0	35.0	NVA
47	24	18.0	25.0	7.0	14.0	28.0	26.0	15.0	21.0	8.0	NVA
48	24	7.5	6.0	12.0	4.0	5.0	5.0	9.0	10.0	9.0	HY
49	24	6.6	11.0	11.0	9.0	2.0	10.0	3.0	5.0	2.0	NVA
50	24	17.6	20.0	16.0	23.0	10.0	12.0	16.0	16.0	28.0	NVA
51	24	9.9	1.0	18.0	13.0	16.0	9.0	10.0	7.0	5.0	NVA
52	25	2.9	1.0	2.0	6.0	3.0	2.0	5.0	0.0	4.0	NVA
53	25	26.9	32.0	39.0	39.0	0.0	36.0	31.0	30.0	8.0	HY
54	25	25.1	32.0	31.0	17.0	30.0	1.0	33.0	23.0	34.0	HY
55	25	26.5	17.0	35.0	47.0	52.0	22.0	20.0	7.0	12.0	NVA
56	25	28.4	44.0	32.0	34.0	20.0	29.0	22.0	17.0	29.0	NVA
57	25	19.5	28.0	49.0	17.0	3.0	18.0	14.0	15.0	12.0	HY
58	25	31.4	54.0	18.0	15.0	57.0	43.0	15.0	2.0	47.0	NVA
59	25	10.3	5.0	7.0	7.0	27.0	4.0	23.0	7.0	2.0	NVA
60	25	12.0	12.0	3.0	1.0	30.0	13.0	7.0	13.0	17.0	HY
61	25	3.9	1.0	11.0	1.0	3.0	0.0	4.0	9.0	2.0	NVA
62	25	22.8	8.0	7.0	49.0	14.0	27.0	13.0	48.0	16.0	NVA
63	25	21.1	20.0	9.0	40.0	15.0	17.0	35.0	16.0	17.0	HY
64	26	6.1	4.0	3.0	5.0	11.0	4.0	10.0	9.0	3.0	HY
65	26	11.3	6.0	9.0	35.0	14.0	18.0	5.0	2.0	1.0	HY
66	26	17.3	15.0	24.0	17.0	22.0	20.0	3.0	11.0	26.0	NVA
67	26	12.4	4.0	20.0	13.0	14.0	5.0	9.0	19.0	15.0	NVA
68	26	16.6	10.0	22.0	15.0	27.0	8.0	15.0	21.0	15.0	HY
69	26	9.3	0.0	3.0	12.0	15.0	14.0	9.0	9.0	12.0	HY
70	26	39.9	35.0	49.0	61.0	1.0	60.0	63.0	2.0	48.0	NVA
71	26	30.4	25.0	50.0	34.0	25.0	18.0	4.0	40.0	47.0	HY
72	26	24.5	11.0	9.0	25.0	20.0	32.0	5.0	45.0	49.0	NVA
73	26	12.4	13.0	16.0	5.0	16.0	11.0	12.0	17.0	9.0	NVA
74	27	36.6	43.0	12.0	32.0	55.0	47.0	46.0	44.0	14.0	HY
75	27	8.1	9.0	1.0	9.0	8.0	10.0	14.0	1.0	13.0	NVA
76	27	21.6	23.0	12.0	29.0	8.0	1.0	4.0	70.0	26.0	NVA

Table B.1: Cross Creek Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
77	27	34.4	48.0	50.0	5.0	38.0	44.0	11.0	33.0	46.0	NVA
78	27	23.5	27.0	29.0	4.0	26.0	27.0	12.0	21.0	42.0	NVA
79	27	24.4	30.0	17.0	1.0	27.0	8.0	43.0	26.0	43.0	NVA
80	27	25.5	26.0	34.0	35.0	51.0	18.0	1.0	38.0	1.0	HY
81	27	7.3	12.0	2.0	15.0	5.0	4.0	6.0	10.0	4.0	NVA
82	27	33.9	33.0	38.0	42.0	40.0	18.0	40.0	39.0	21.0	NVA
83	28	41.5	62.0	47.0	58.0	31.0	52.0	41.0	1.0	40.0	NVA
84	28	24.4	38.0	2.0	35.0	23.0	17.0	20.0	36.0	24.0	NVA
85	28	11.6	5.0	1.0	24.0	12.0	1.0	30.0	4.0	16.0	HY
86	28	26.1	7.0	29.0	16.0	52.0	30.0	40.0	12.0	23.0	HY
87	28	5.9	0.0	5.0	9.0	10.0	4.0	8.0	11.0	0.0	NVA
88	28	14.9	18.0	8.0	32.0	1.0	3.0	8.0	7.0	42.0	HY
89	28	2.6	8.0	4.0	0.0	1.0	1.0	1.0	4.0	2.0	HY
90	28	22.9	34.0	26.0	10.0	4.0	36.0	42.0	19.0	12.0	HY
91	28	32.1	33.0	4.0	45.0	48.0	58.0	2.0	35.0	32.0	HY
92	29	34.8	26.0	40.0	44.0	57.0	25.0	12.0	20.0	54.0	NVA
93	29	31.0	10.0	39.0	38.0	43.0	4.0	21.0	48.0	45.0	HY
94	29	14.9	9.0	12.0	27.0	12.0	2.0	17.0	23.0	17.0	NVA
95	29	31.1	39.0	21.0	7.0	8.0	59.0	60.0	27.0	28.0	NVA
96	29	33.3	29.0	47.0	55.0	17.0	52.0	39.0	5.0	22.0	NVA
97	29	33.3	28.0	14.0	6.0	30.0	44.0	51.0	56.0	37.0	NVA
98	29	9.9	16.0	14.0	13.0	6.0	0.0	18.0	12.0	0.0	HY
99	29	15.4	14.0	22.0	1.0	27.0	7.0	14.0	8.0	30.0	HY
100	29	40.0	71.0	12.0	60.0	24.0	40.0	35.0	55.0	23.0	NVA
101	30	21.3	28.0	18.0	30.0	2.0	39.0	39.0	4.0	10.0	HY
102	30	22.4	3.0	17.0	31.0	32.0	15.0	23.0	22.0	36.0	HY
103	30	20.0	36.0	19.0	2.0	22.0	37.0	0.0	28.0	16.0	NVA
104	30	22.5	23.0	27.0	3.0	20.0	33.0	19.0	31.0	24.0	HY
105	30	15.6	17.0	19.0	20.0	6.0	25.0	12.0	11.0	15.0	NVA
106	30	6.6	10.0	4.0	8.0	6.0	5.0	5.0	3.0	12.0	NVA
107	30	4.3	11.0	3.0	4.0	6.0	3.0	2.0	0.0	5.0	NVA
108	31	20.8	16.0	17.0	20.0	22.0	14.0	15.0	45.0	17.0	NVA
109	31	2.9	5.0	3.0	4.0	3.0	1.0	5.0	0.0	2.0	NVA
110	31	34.5	14.0	59.0	54.0	8.0	46.0	46.0	26.0	23.0	NVA
111	31	22.1	16.0	14.0	7.0	42.0	11.0	29.0	19.0	39.0	HY
112	31	33.1	29.0	18.0	1.0	18.0	62.0	46.0	36.0	55.0	NVA
113	31	29.4	29.0	20.0	32.0	47.0	36.0	31.0	31.0	9.0	NVA
114	31	6.9	8.0	1.0	2.0	15.0	5.0	4.0	6.0	14.0	NVA
115	32	2.1	2.0	1.0	4.0	3.0	1.0	3.0	1.0	2.0	NVA
116	32	19.4	23.0	15.0	29.0	9.0	28.0	7.0	21.0	23.0	NVA
117	32	30.8	23.0	38.0	6.0	46.0	51.0	7.0	73.0	2.0	NVA
118	32	30.0	0.0	29.0	15.0	15.0	65.0	56.0	21.0	39.0	NVA
119	32	10.5	15.0	3.0	23.0	1.0	12.0	5.0	8.0	17.0	HY
120	32	31.3	21.0	21.0	40.0	19.0	7.0	41.0	51.0	50.0	HY
121	32	19.4	6.0	10.0	31.0	29.0	30.0	12.0	11.0	26.0	NVA
122	33	26.0	62.0	1.0	46.0	6.0	16.0	55.0	9.0	13.0	HY
123	33	26.3	36.0	36.0	2.0	11.0	20.0	77.0	9.0	19.0	HY
124	33	18.5	12.0	3.0	32.0	10.0	8.0	40.0	23.0	20.0	NVA
125	33	27.0	26.0	46.0	41.0	38.0	26.0	23.0	10.0	6.0	NVA
126	33	28.1	49.0	44.0	45.0	21.0	33.0	10.0	20.0	3.0	HY
127	33	4.4	3.0	4.0	10.0	1.0	4.0	1.0	9.0	3.0	HY
128	34	33.6	19.0	23.0	43.0	42.0	34.0	44.0	1.0	63.0	NVA
129	34	14.1	4.0	22.0	7.0	10.0	27.0	15.0	17.0	11.0	HY
130	34	21.6	25.0	39.0	36.0	19.0	4.0	12.0	17.0	21.0	NVA
131	34	41.6	6.0	60.0	41.0	80.0	48.0	4.0	71.0	23.0	NVA
132	34	19.4	9.0	26.0	23.0	19.0	14.0	28.0	21.0	15.0	NVA
133	34	3.9	2.0	3.0	9.0	8.0	3.0	3.0	3.0	0.0	NVA
134	35	8.4	0.0	8.0	9.0	12.0	5.0	12.0	9.0	12.0	NVA
135	35	42.0	37.0	82.0	44.0	21.0	12.0	71.0	61.0	8.0	NVA
136	35	25.1	12.0	47.0	42.0	46.0	1.0	18.0	35.0	0.0	NVA

Table B.1: Cross Creek Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
137	35	48.5	74.0	48.0	8.0	64.0	59.0	46.0	10.0	79.0	NVA
138	35	19.9	5.0	17.0	36.0	26.0	18.0	9.0	35.0	13.0	NVA
139	36	28.4	33.0	13.0	26.0	34.0	20.0	16.0	35.0	50.0	NVA
140	36	4.9	2.0	7.0	7.0	1.0	9.0	7.0	0.0	6.0	NVA
141	36	2.9	4.0	3.0	5.0	0.0	3.0	3.0	3.0	2.0	HY
142	36	45.6	52.0	39.0	36.0	40.0	34.0	56.0	83.0	25.0	HY
143	36	7.3	5.0	11.0	6.0	11.0	11.0	6.0	4.0	4.0	NVA
144	37	44.4	24.0	51.0	89.0	23.0	82.0	28.0	14.0	44.0	NVA
145	37	8.1	0.0	6.0	22.0	4.0	0.0	11.0	2.0	20.0	HY
146	37	17.4	1.0	9.0	3.0	45.0	38.0	31.0	5.0	7.0	NVA
147	37	14.4	13.0	21.0	18.0	5.0	7.0	11.0	25.0	15.0	NVA
148	37	35.5	59.0	8.0	25.0	64.0	68.0	3.0	12.0	45.0	NVA
149	38	38.8	12.0	53.0	42.0	49.0	42.0	62.0	24.0	26.0	NVA
150	38	14.3	7.0	27.0	25.0	11.0	11.0	18.0	6.0	9.0	NVA
151	38	2.3	1.0	2.0	4.0	1.0	1.0	1.0	4.0	4.0	NVA
152	38	21.6	16.0	10.0	10.0	38.0	36.0	38.0	3.0	22.0	NVA
153	38	15.4	34.0	18.0	10.0	4.0	6.0	7.0	9.0	35.0	HY
154	39	2.8	6.0	1.0	3.0	1.0	2.0	0.0	4.0	5.0	NVA
155	39	10.9	19.0	1.0	1.0	19.0	12.0	4.0	19.0	12.0	NVA
156	39	36.5	36.0	26.0	53.0	63.0	19.0	63.0	7.0	25.0	HY
157	39	33.4	40.0	20.0	44.0	37.0	30.0	35.0	43.0	18.0	NVA
158	40	16.3	13.0	17.0	9.0	8.0	28.0	23.0	26.0	6.0	NVA
159	40	4.3	3.0	7.0	7.0	1.0	8.0	5.0	3.0	0.0	HY
160	40	32.0	32.0	76.0	23.0	26.0	9.0	49.0	26.0	15.0	HY
161	40	53.6	26.0	84.0	0.0	76.0	9.0	64.0	84.0	86.0	NVA
162	41	2.8	3.0	2.0	6.0	3.0	2.0	1.0	4.0	1.0	NVA
163	41	29.9	8.0	44.0	41.0	27.0	15.0	33.0	31.0	40.0	HY
164	41	7.3	8.0	3.0	15.0	15.0	6.0	2.0	8.0	1.0	HY
165	41	7.9	3.0	15.0	1.0	8.0	6.0	9.0	17.0	4.0	NVA
166	42	20.0	16.0	13.0	19.0	17.0	32.0	26.0	7.0	30.0	HY
167	42	14.0	6.0	13.0	7.0	13.0	19.0	12.0	20.0	22.0	NVA
168	42	5.0	11.0	1.0	7.0	2.0	10.0	4.0	2.0	3.0	NVA
169	42	9.8	4.0	21.0	1.0	14.0	18.0	1.0	10.0	9.0	NVA
170	43	8.4	3.0	7.0	14.0	10.0	1.0	3.0	6.0	23.0	NVA
171	43	2.5	4.0	3.0	3.0	2.0	0.0	4.0	2.0	2.0	NVA
172	43	13.3	14.0	11.0	22.0	11.0	5.0	18.0	8.0	17.0	HY
173	44	5.5	3.0	9.0	1.0	8.0	3.0	4.0	8.0	8.0	NVA
174	44	27.3	31.0	44.0	21.0	19.0	42.0	44.0	5.0	12.0	NVA
175	44	36.5	6.0	13.0	55.0	30.0	1.0	84.0	28.0	75.0	NVA
176	44	55.0	78.0	69.0	10.0	19.0	35.0	77.0	76.0	76.0	HY
177	45	21.4	10.0	5.0	1.0	26.0	27.0	37.0	27.0	38.0	NVA
178	45	42.0	51.0	38.0	60.0	48.0	49.0	28.0	10.0	52.0	NVA
179	45	26.6	51.0	46.0	1.0	48.0	12.0	8.0	13.0	34.0	HY
180	46	17.8	19.0	32.0	33.0	4.0	10.0	1.0	31.0	12.0	NVA
181	46	3.8	4.0	4.0	5.0	1.0	2.0	3.0	6.0	5.0	NVA
182	46	37.9	14.0	41.0	27.0	37.0	37.0	59.0	45.0	43.0	NVA
183	47	2.5	1.0	3.0	2.0	1.0	4.0	2.0	5.0	2.0	NVA
184	47	71.0	90.0	62.0	89.0	21.0	32.0	84.0	83.0	107.0	NVA
185	47	20.5	4.0	1.0	18.0	21.0	32.0	34.0	30.0	24.0	NVA
186	48	64.1	71.0	23.0	63.0	33.0	84.0	75.0	82.0	82.0	NVA
187	48	51.8	58.0	95.0	14.0	86.0	57.0	1.0	52.0	51.0	HY
188	49	28.0	15.0	42.0	63.0	14.0	28.0	36.0	23.0	3.0	NVA
189	49	54.6	67.0	49.0	17.0	104.0	63.0	9.0	106.0	22.0	NVA
190	49	61.5	72.0	75.0	64.0	21.0	76.0	73.0	56.0	55.0	NVA
191	50	64.4	116.0	27.0	64.0	55.0	32.0	21.0	100.0	100.0	NVA
192	50	35.1	74.0	4.0	40.0	5.0	72.0	29.0	48.0	9.0	NVA
193	50	22.9	1.0	46.0	37.0	40.0	8.0	16.0	26.0	9.0	HY
194	51	28.3	50.0	33.0	27.0	21.0	16.0	27.0	34.0	18.0	HY
195	51	2.9	2.0	3.0	0.0	2.0	4.0	5.0	4.0	3.0	HY
196	52	50.6	80.0	48.0	86.0	29.0	20.0	14.0	36.0	92.0	NVA

Table B.1: Cross Creek Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
197	52	38.4	15.0	45.0	24.0	37.0	26.0	58.0	57.0	45.0	NVA
198	53	78.1	80.0	76.0	94.0	38.0	105.0	32.0	97.0	103.0	HY
199	53	30.6	8.0	18.0	21.0	29.0	6.0	35.0	75.0	53.0	NVA
200	53	46.0	11.0	82.0	36.0	79.0	8.0	8.0	70.0	74.0	HY
201	54	34.0	61.0	16.0	50.0	17.0	20.0	54.0	29.0	25.0	NVA
202	54	20.6	16.0	38.0	21.0	28.0	35.0	4.0	21.0	2.0	HY
203	55	38.1	7.0	21.0	70.0	64.0	4.0	19.0	72.0	48.0	HY
204	55	88.4	109.0	82.0	75.0	58.0	100.0	101.0	114.0	68.0	HY
205	56	12.4	15.0	3.0	17.0	2.0	31.0	16.0	8.0	7.0	NVA
206	56	80.8	18.0	52.0	118.0	146.0	82.0	66.0	127.0	37.0	NVA
207	57	48.1	42.0	34.0	51.0	64.0	73.0	37.0	42.0	42.0	NVA
208	57	76.9	20.0	129.0	95.0	36.0	113.0	85.0	12.0	125.0	NVA
209	58	73.1	68.0	81.0	128.0	36.0	9.0	127.0	101.0	35.0	HY
210	59	33.1	54.0	44.0	24.0	30.0	8.0	43.0	59.0	3.0	NVA
211	59	28.1	38.0	16.0	32.0	9.0	33.0	16.0	34.0	47.0	NVA
212	60	49.1	66.0	60.0	31.0	61.0	32.0	66.0	12.0	65.0	NVA
213	60	28.6	56.0	40.0	8.0	41.0	10.0	10.0	30.0	34.0	NVA
214	61	67.4	120.0	118.0	94.0	28.0	93.0	13.0	63.0	10.0	NVA
215	61	4.0	3.0	1.0	5.0	2.0	5.0	6.0	4.0	6.0	NVA
216	62	64.5	70.0	107.0	13.0	1.0	132.0	93.0	87.0	13.0	HY
217	63	67.5	80.0	39.0	46.0	61.0	93.0	92.0	48.0	81.0	NVA
218	63	72.6	86.0	15.0	55.0	97.0	93.0	84.0	97.0	54.0	NVA
219	64	3.3	0.0	4.0	3.0	2.0	2.0	5.0	3.0	7.0	NVA
220	65	43.5	63.0	26.0	36.0	31.0	49.0	58.0	47.0	38.0	NVA
221	65	30.3	16.0	30.0	34.0	65.0	35.0	40.0	1.0	21.0	NVA
222	66	32.0	34.0	50.0	41.0	4.0	45.0	2.0	38.0	42.0	HY
223	67	27.5	6.0	13.0	44.0	46.0	17.0	17.0	39.0	38.0	HY
224	68	14.6	15.0	11.0	22.0	4.0	16.0	25.0	11.0	13.0	NVA
225	68	21.5	36.0	29.0	25.0	15.0	4.0	8.0	24.0	31.0	NVA
226	69	91.9	169.0	51.0	90.0	112.0	87.0	38.0	56.0	132.0	NVA
227	70	48.0	27.0	59.0	52.0	28.0	53.0	73.0	32.0	60.0	HY
228	71	27.8	25.0	18.0	33.0	6.0	13.0	53.0	31.0	43.0	NVA
229	72	58.6	99.0	14.0	32.0	31.0	53.0	112.0	100.0	28.0	NVA
230	73	74.6	65.0	147.0	66.0	119.0	78.0	17.0	78.0	27.0	NVA
231	73	44.9	72.0	17.0	68.0	17.0	27.0	47.0	81.0	30.0	HY
232	74	100.0	73.0	99.0	192.0	32.0	98.0	176.0	70.0	60.0	NVA
233	75	25.6	27.0	37.0	18.0	22.0	41.0	29.0	23.0	8.0	NVA
234	76	69.6	132.0	28.0	89.0	91.0	84.0	81.0	28.0	24.0	NVA
235	77	71.9	6.0	19.0	83.0	59.0	124.0	118.0	86.0	80.0	NVA
236	78	51.9	82.0	70.0	77.0	75.0	41.0	37.0	27.0	6.0	NVA
237	79	32.9	34.0	35.0	48.0	35.0	27.0	31.0	28.0	25.0	NVA
238	80	6.0	6.0	2.0	6.0	5.0	11.0	2.0	7.0	9.0	NVA
239	82	98.0	64.0	90.0	83.0	160.0	115.0	42.0	141.0	89.0	NVA
240	83	39.3	62.0	54.0	44.0	12.0	48.0	81.0	3.0	10.0	HY
241	84	51.1	85.0	57.0	39.0	103.0	68.0	4.0	50.0	3.0	NVA
242	85	27.6	41.0	25.0	46.0	9.0	28.0	37.0	23.0	12.0	HY
243	86	30.6	35.0	1.0	59.0	24.0	11.0	30.0	44.0	41.0	NVA
244	88	153.1	198.0	117.0	212.0	171.0	216.0	76.0	169.0	66.0	NVA
245	89	104.8	77.0	140.0	119.0	113.0	99.0	71.0	87.0	132.0	NVA
246	91	2.4	0.0	0.0	2.0	3.0	4.0	2.0	5.0	3.0	HY
247	92	56.9	46.0	72.0	17.0	81.0	66.0	73.0	82.0	18.0	NVA
248	94	51.0	85.0	97.0	53.0	7.0	58.0	10.0	69.0	29.0	NVA
249	95	32.1	34.0	3.0	43.0	21.0	32.0	14.0	64.0	46.0	NVA
250	97	126.5	150.0	25.0	201.0	171.0	130.0	31.0	151.0	153.0	NVA
251	98	85.4	1.0	132.0	67.0	110.0	31.0	129.0	77.0	136.0	NVA
252	100	63.6	139.0	46.0	13.0	28.0	117.0	51.0	4.0	111.0	NVA
253	102	133.0	129.0	44.0	212.0	97.0	170.0	79.0	119.0	214.0	HY
254	104	55.3	28.0	6.0	82.0	22.0	78.0	67.0	81.0	78.0	NVA
255	106	11.0	19.0	2.0	3.0	12.0	7.0	15.0	18.0	12.0	NVA
256	108	130.6	116.0	177.0	140.0	156.0	181.0	95.0	66.0	114.0	NVA

Table B.1: Cross Creek Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
257	110	119.4	221.0	36.0	39.0	141.0	212.0	96.0	101.0	109.0	NVA
258	112	136.5	168.0	96.0	13.0	216.0	256.0	168.0	118.0	57.0	HY
259	114	54.9	52.0	71.0	9.0	57.0	48.0	69.0	57.0	76.0	NVA
260	117	37.8	10.0	51.0	38.0	53.0	36.0	46.0	14.0	54.0	NVA
261	119	83.1	74.0	103.0	74.0	131.0	67.0	31.0	30.0	155.0	NVA
262	122	48.9	79.0	41.0	23.0	70.0	49.0	47.0	54.0	28.0	NVA
263	125	121.3	231.0	124.0	28.0	86.0	154.0	202.0	47.0	98.0	HY
264	128	58.3	48.0	22.0	44.0	104.0	99.0	41.0	13.0	95.0	NVA
265	131	42.5	36.0	43.0	47.0	48.0	59.0	50.0	41.0	16.0	NVA
266	134	48.0	28.0	17.0	23.0	71.0	74.0	51.0	29.0	91.0	NVA
267	138	131.8	270.0	109.0	70.0	25.0	72.0	5.0	189.0	314.0	NVA
268	141	188.4	310.0	337.0	89.0	179.0	50.0	241.0	103.0	198.0	NVA
269	145	198.0	202.0	342.0	104.0	39.0	271.0	179.0	162.0	285.0	NVA
270	149	4.4	6.0	3.0	4.0	7.0	1.0	3.0	6.0	5.0	NVA
271	154	174.4	223.0	315.0	235.0	133.0	55.0	256.0	66.0	112.0	NVA
272	158	195.1	0.0	121.0	176.0	269.0	326.0	272.0	53.0	344.0	NVA
273	163	49.9	36.0	42.0	70.0	20.0	68.0	74.0	69.0	20.0	NVA
274	168	57.3	5.0	52.0	81.0	45.0	68.0	50.0	65.0	92.0	NVA
275	174	128.1	140.0	79.0	85.0	131.0	140.0	168.0	100.0	182.0	NVA
276	180	212.6	406.0	37.0	86.0	228.0	27.0	376.0	319.0	222.0	NVA
277	187	221.1	210.0	256.0	46.0	196.0	225.0	269.0	312.0	255.0	NVA
278	194	71.0	123.0	180.0	59.0	26.0	51.0	0.0	68.0	61.0	NVA
279	202	17.1	8.0	30.0	13.0	10.0	4.0	26.0	15.0	31.0	NVA
280	210	144.6	203.0	197.0	26.0	43.0	140.0	199.0	122.0	227.0	NVA
281	219	48.6	27.0	47.0	49.0	103.0	44.0	13.0	81.0	25.0	NVA
282	230	255.4	135.0	404.0	368.0	256.0	132.0	32.0	186.0	530.0	HY
283	241	28.1	24.0	67.0	6.0	40.0	13.0	4.0	34.0	37.0	HY
284	253	278.8	374.0	164.0	48.0	313.0	474.0	283.0	99.0	475.0	NVA
285	267	139.9	111.0	187.0	76.0	162.0	98.0	191.0	103.0	191.0	HY
286	283	358.8	520.0	287.0	486.0	384.0	416.0	32.0	173.0	572.0	HY
287	301	121.0	150.0	192.0	47.0	180.0	75.0	197.0	0.0	127.0	HY
288	322	117.9	164.0	136.0	33.0	126.0	51.0	177.0	87.0	169.0	HY
289	346	385.1	764.0	346.0	435.0	33.0	506.0	789.0	124.0	84.0	NVA
290	374	76.6	78.0	64.0	62.0	77.0	103.0	51.0	65.0	113.0	HY
291	408	189.9	180.0	328.0	267.0	171.0	189.0	176.0	23.0	185.0	HY
292	449	276.4	90.0	157.0	463.0	81.0	439.0	277.0	677.0	27.0	NVA
293	500	66.8	128.0	52.0	70.0	2.0	131.0	10.0	87.0	54.0	NVA
294	566	349.8	533.0	1.0	30.0	400.0	461.0	791.0	462.0	120.0	HY
295	654	716.8	274.0	671.0	1232.0	724.0	910.0	169.0	1099.0	655.0	HY
296	778	410.3	117.0	143.0	264.0	139.0	486.0	738.0	839.0	556.0	HY
297	968	218.0	397.0	450.0	3.0	88.0	1.0	317.0	324.0	164.0	NVA
298	1300	717.1	1023.0	25.0	1328.0	1079.0	573.0	135.0	1235.0	339.0	HY
299	2060	2122.3	2209.0	2104.0	1059.0	1158.0	2024.0	2955.0	2511.0	2958.0	NVA
300	20365	14071.8	18155.0	15498.0	1092.0	24565.0	8921.0	20914.0	21938.0	1491.0	HY

Appendix C

Cross Creek Example Data – Separate

In this appendix we present the separate data for the Cross Creek example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Ave. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table C.1: Cross Creek Example Data – Separate NVA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
4	21	4.8	3.0	5.0	6.0	5.0	5.0	5.0	3.0	6.0	HY - NVA
5	21	15.6	14.0	17.0	15.0	13.0	7.0	21.0	17.0	21.0	HY - NVA
13	22	16.0	6.0	14.0	17.0	8.0	22.0	18.0	21.0	22.0	HY - NVA
20	22	4.1	1.0	5.0	4.0	6.0	6.0	3.0	2.0	6.0	HY - NVA
23	22	8.1	2.0	8.0	4.0	10.0	1.0	17.0	6.0	17.0	HY - NVA
24	22	19.4	12.0	36.0	2.0	23.0	32.0	12.0	2.0	36.0	HY - NVA
25	22	12.6	14.0	0.0	7.0	12.0	19.0	19.0	11.0	19.0	HY - NVA
27	23	22.6	11.0	26.0	31.0	10.0	32.0	21.0	14.0	36.0	HY - NVA
28	23	3.9	1.0	3.0	3.0	6.0	5.0	2.0	5.0	6.0	HY - NVA
32	23	22.6	38.0	30.0	5.0	15.0	10.0	19.0	26.0	38.0	HY - NVA
33	23	19.5	12.0	6.0	3.0	1.0	33.0	35.0	31.0	35.0	HY - NVA
39	23	21.4	0.0	12.0	33.0	19.0	19.0	14.0	37.0	37.0	HY - NVA
42	24	16.1	19.0	19.0	0.0	28.0	21.0	12.0	2.0	28.0	HY - NVA
48	24	6.3	9.0	3.0	4.0	4.0	7.0	7.0	7.0	9.0	HY - NVA
53	25	19.9	28.0	28.0	0.0	26.0	22.0	21.0	6.0	28.0	HY - NVA
54	25	18.1	22.0	12.0	21.0	1.0	24.0	17.0	24.0	24.0	HY - NVA
57	25	16.0	35.0	12.0	3.0	13.0	10.0	11.0	9.0	35.0	HY - NVA
60	25	10.4	3.0	1.0	21.0	10.0	5.0	10.0	12.0	21.0	HY - NVA
63	25	16.9	7.0	28.0	11.0	12.0	25.0	12.0	12.0	28.0	HY - NVA
64	26	5.4	3.0	4.0	8.0	3.0	7.0	7.0	3.0	8.0	HY - NVA

Table C.1: Cross Creek Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
65	26	10.9	7.0	25.0	10.0	13.0	4.0	2.0	1.0	25.0	HY - NVA
68	26	13.5	16.0	11.0	19.0	6.0	11.0	15.0	11.0	19.0	HY - NVA
69	26	8.4	3.0	9.0	11.0	10.0	7.0	7.0	9.0	11.0	HY - NVA
71	26	23.6	35.0	24.0	18.0	13.0	3.0	28.0	33.0	35.0	HY - NVA
74	27	27.1	9.0	23.0	39.0	33.0	33.0	31.0	10.0	39.0	HY - NVA
80	27	20.4	24.0	25.0	36.0	13.0	1.0	27.0	1.0	36.0	HY - NVA
85	28	10.6	1.0	17.0	9.0	1.0	21.0	3.0	12.0	21.0	HY - NVA
86	28	22.8	21.0	12.0	37.0	21.0	28.0	9.0	17.0	37.0	HY - NVA
88	28	13.0	6.0	23.0	1.0	3.0	6.0	5.0	30.0	30.0	HY - NVA
89	28	2.1	3.0	0.0	1.0	1.0	1.0	3.0	2.0	6.0	HY - NVA
90	28	17.3	19.0	7.0	3.0	26.0	30.0	14.0	9.0	30.0	HY - NVA
91	28	25.1	3.0	32.0	34.0	41.0	2.0	25.0	23.0	41.0	HY - NVA
93	29	25.5	28.0	27.0	31.0	3.0	15.0	34.0	32.0	34.0	HY - NVA
98	29	7.5	10.0	10.0	5.0	0.0	13.0	9.0	0.0	13.0	HY - NVA
99	29	12.4	16.0	1.0	19.0	5.0	10.0	6.0	21.0	21.0	HY - NVA
101	30	16.3	13.0	21.0	2.0	28.0	28.0	3.0	7.0	28.0	HY - NVA
102	30	19.1	12.0	22.0	23.0	11.0	17.0	16.0	26.0	26.0	HY - NVA
104	30	17.1	19.0	3.0	14.0	24.0	14.0	22.0	17.0	24.0	HY - NVA
111	31	18.3	10.0	5.0	30.0	8.0	21.0	14.0	28.0	30.0	HY - NVA
119	32	8.6	3.0	17.0	1.0	9.0	4.0	6.0	12.0	17.0	HY - NVA
120	32	24.8	15.0	28.0	14.0	5.0	29.0	36.0	35.0	36.0	HY - NVA
122	33	18.9	1.0	33.0	5.0	12.0	39.0	7.0	10.0	44.0	HY - NVA
123	33	22.4	26.0	2.0	8.0	14.0	54.0	7.0	14.0	54.0	HY - NVA
126	33	20.1	31.0	32.0	15.0	24.0	7.0	14.0	3.0	35.0	HY - NVA
127	33	4.0	3.0	7.0	1.0	3.0	1.0	7.0	3.0	7.0	HY - NVA
129	34	12.1	16.0	5.0	7.0	19.0	11.0	12.0	8.0	19.0	HY - NVA
141	36	2.8	3.0	4.0	0.0	3.0	3.0	3.0	2.0	4.0	HY - NVA
142	36	35.3	28.0	26.0	28.0	24.0	40.0	59.0	18.0	59.0	HY - NVA
145	37	8.0	5.0	16.0	3.0	0.0	8.0	2.0	14.0	16.0	HY - NVA
153	38	11.3	13.0	7.0	3.0	5.0	5.0	7.0	25.0	25.0	HY - NVA
156	39	28.6	19.0	38.0	45.0	14.0	45.0	5.0	18.0	45.0	HY - NVA
159	40	3.8	5.0	5.0	1.0	6.0	4.0	3.0	0.0	6.0	HY - NVA
160	40	27.0	54.0	17.0	19.0	7.0	35.0	19.0	11.0	54.0	HY - NVA
163	41	24.4	31.0	29.0	19.0	11.0	24.0	22.0	28.0	31.0	HY - NVA
164	41	6.3	3.0	11.0	11.0	5.0	2.0	6.0	1.0	11.0	HY - NVA
166	42	15.9	10.0	14.0	12.0	23.0	19.0	5.0	21.0	23.0	HY - NVA
172	43	10.4	8.0	16.0	8.0	4.0	13.0	6.0	12.0	16.0	HY - NVA
176	44	39.0	49.0	7.0	14.0	25.0	54.0	54.0	54.0	55.0	HY - NVA
179	45	19.1	33.0	1.0	34.0	9.0	6.0	10.0	24.0	36.0	HY - NVA
187	48	39.9	67.0	10.0	61.0	40.0	1.0	37.0	36.0	67.0	HY - NVA
193	50	20.5	33.0	26.0	28.0	6.0	12.0	19.0	7.0	33.0	HY - NVA
194	51	20.1	24.0	19.0	15.0	12.0	19.0	24.0	13.0	35.0	HY - NVA
195	51	2.8	3.0	0.0	2.0	3.0	4.0	3.0	3.0	4.0	HY - NVA
198	53	57.4	54.0	66.0	27.0	74.0	23.0	68.0	73.0	74.0	HY - NVA
200	53	38.9	58.0	26.0	56.0	6.0	6.0	49.0	52.0	58.0	HY - NVA
202	54	16.8	27.0	15.0	20.0	25.0	3.0	15.0	2.0	27.0	HY - NVA
203	55	32.8	15.0	49.0	45.0	3.0	14.0	51.0	34.0	51.0	HY - NVA
204	55	62.6	58.0	53.0	41.0	70.0	71.0	80.0	48.0	80.0	HY - NVA
209	58	56.9	57.0	90.0	26.0	7.0	89.0	71.0	25.0	90.0	HY - NVA
216	62	51.1	75.0	10.0	1.0	93.0	66.0	61.0	10.0	93.0	HY - NVA
222	66	24.1	35.0	29.0	3.0	32.0	2.0	27.0	30.0	35.0	HY - NVA
223	67	23.3	10.0	31.0	33.0	12.0	12.0	28.0	27.0	33.0	HY - NVA
227	70	38.3	42.0	37.0	20.0	38.0	52.0	23.0	42.0	52.0	HY - NVA
231	73	32.4	12.0	48.0	12.0	19.0	33.0	57.0	21.0	57.0	HY - NVA
240	83	29.5	38.0	31.0	9.0	34.0	57.0	3.0	7.0	57.0	HY - NVA
242	85	20.4	18.0	33.0	7.0	20.0	26.0	17.0	9.0	33.0	HY - NVA
246	91	2.6	0.0	2.0	3.0	3.0	2.0	4.0	3.0	4.0	HY - NVA
253	102	100.9	31.0	149.0	68.0	119.0	56.0	84.0	150.0	150.0	HY - NVA
258	112	103.9	68.0	10.0	152.0	180.0	118.0	83.0	40.0	180.0	HY - NVA
263	125	85.3	87.0	20.0	61.0	108.0	142.0	33.0	69.0	162.0	HY - NVA

Table C.1: Cross Creek Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
282	230	213.8	283.0	258.0	180.0	93.0	23.0	131.0	371.0	371.0	HY - NVA
283	241	23.8	47.0	5.0	28.0	10.0	3.0	24.0	26.0	47.0	HY - NVA
285	267	105.4	131.0	54.0	114.0	69.0	134.0	73.0	134.0	134.0	HY - NVA
286	283	256.3	201.0	341.0	269.0	292.0	23.0	122.0	401.0	401.0	HY - NVA
287	301	89.0	135.0	33.0	126.0	53.0	138.0	0.0	89.0	138.0	HY - NVA
288	322	84.1	96.0	24.0	89.0	36.0	124.0	61.0	119.0	124.0	HY - NVA
290	374	57.3	45.0	44.0	54.0	73.0	36.0	46.0	80.0	80.0	HY - NVA
291	408	146.4	230.0	187.0	120.0	133.0	124.0	17.0	130.0	230.0	HY - NVA
294	566	267.6	1.0	21.0	280.0	323.0	554.0	324.0	84.0	554.0	HY - NVA
295	654	586.0	470.0	863.0	507.0	637.0	119.0	770.0	459.0	863.0	HY - NVA
296	778	351.0	101.0	185.0	98.0	341.0	517.0	588.0	390.0	588.0	HY - NVA
298	1300	529.3	18.0	930.0	756.0	402.0	95.0	865.0	238.0	930.0	HY - NVA
300	20365	10411.5	10849.0	765.0	17196.0	6245.0	14640.0	15357.0	1044.0	17196.0	HY - NVA
1	21	21.1	20.0	7.0	19.0	32.0	36.0	50.0	4.0	1.0	NVA
2	21	6.9	2.0	11.0	8.0	11.0	8.0	3.0	8.0	4.0	NVA
3	21	27.3	32.0	40.0	3.0	42.0	0.0	29.0	41.0	31.0	NVA
6	21	4.6	5.0	4.0	7.0	5.0	3.0	2.0	6.0	5.0	NVA
7	21	16.8	25.0	28.0	29.0	8.0	3.0	2.0	25.0	14.0	NVA
8	21	8.0	8.0	4.0	12.0	1.0	7.0	10.0	11.0	11.0	NVA
9	21	15.5	2.0	7.0	29.0	18.0	10.0	6.0	26.0	26.0	NVA
10	21	4.1	4.0	7.0	4.0	3.0	3.0	2.0	6.0	4.0	NVA
11	21	2.4	0.0	0.0	4.0	4.0	1.0	4.0	3.0	3.0	NVA
12	22	4.9	5.0	8.0	5.0	10.0	2.0	2.0	5.0	2.0	NVA
14	22	7.0	13.0	10.0	13.0	2.0	4.0	8.0	5.0	1.0	NVA
15	22	5.3	2.0	9.0	4.0	4.0	10.0	7.0	0.0	6.0	NVA
16	22	29.8	34.0	45.0	40.0	17.0	16.0	34.0	40.0	12.0	NVA
17	22	17.8	4.0	26.0	32.0	1.0	26.0	2.0	26.0	25.0	NVA
18	22	3.9	5.0	6.0	6.0	4.0	2.0	3.0	4.0	1.0	NVA
19	22	34.8	47.0	36.0	34.0	44.0	29.0	20.0	47.0	21.0	NVA
21	22	10.0	14.0	12.0	6.0	6.0	11.0	4.0	7.0	20.0	NVA
22	22	29.8	9.0	11.0	44.0	32.0	41.0	28.0	35.0	38.0	NVA
26	23	12.5	15.0	3.0	20.0	6.0	10.0	12.0	22.0	12.0	NVA
29	23	12.5	14.0	17.0	6.0	17.0	17.0	15.0	12.0	2.0	NVA
30	23	2.8	3.0	1.0	3.0	3.0	5.0	5.0	2.0	0.0	NVA
31	23	28.1	20.0	21.0	31.0	0.0	25.0	43.0	50.0	35.0	NVA
34	23	3.3	5.0	2.0	5.0	1.0	3.0	2.0	4.0	4.0	NVA
35	23	9.8	21.0	4.0	6.0	12.0	4.0	2.0	18.0	11.0	NVA
36	23	2.8	5.0	4.0	4.0	2.0	1.0	1.0	3.0	2.0	NVA
37	23	13.1	18.0	2.0	6.0	2.0	6.0	48.0	6.0	17.0	NVA
38	23	20.6	39.0	5.0	1.0	5.0	33.0	29.0	44.0	9.0	NVA
40	24	3.0	4.0	4.0	5.0	1.0	2.0	1.0	4.0	3.0	NVA
41	24	26.0	35.0	32.0	32.0	22.0	15.0	30.0	26.0	16.0	NVA
43	24	15.3	19.0	38.0	15.0	8.0	3.0	18.0	4.0	17.0	NVA
44	24	38.0	25.0	47.0	41.0	9.0	51.0	58.0	19.0	54.0	NVA
45	24	3.4	1.0	2.0	3.0	6.0	3.0	3.0	3.0	6.0	NVA
46	24	26.3	27.0	14.0	32.0	12.0	36.0	24.0	30.0	35.0	NVA
47	24	18.0	25.0	7.0	14.0	28.0	26.0	15.0	21.0	8.0	NVA
49	24	6.6	11.0	11.0	9.0	2.0	10.0	3.0	5.0	2.0	NVA
50	24	17.6	20.0	16.0	23.0	10.0	12.0	16.0	16.0	28.0	NVA
51	24	9.9	1.0	18.0	13.0	16.0	9.0	10.0	7.0	5.0	NVA
52	25	2.9	1.0	2.0	6.0	3.0	2.0	5.0	0.0	4.0	NVA
55	25	26.5	17.0	35.0	47.0	52.0	22.0	20.0	7.0	12.0	NVA
56	25	28.4	44.0	32.0	34.0	20.0	29.0	22.0	17.0	29.0	NVA
58	25	31.4	54.0	18.0	15.0	57.0	43.0	15.0	2.0	47.0	NVA
59	25	10.3	5.0	7.0	7.0	27.0	4.0	23.0	7.0	2.0	NVA
61	25	3.9	1.0	11.0	1.0	3.0	0.0	4.0	9.0	2.0	NVA
62	25	22.8	8.0	7.0	49.0	14.0	27.0	13.0	48.0	16.0	NVA
66	26	17.3	15.0	24.0	17.0	22.0	20.0	3.0	11.0	26.0	NVA
67	26	12.4	4.0	20.0	13.0	14.0	5.0	9.0	19.0	15.0	NVA
70	26	39.9	35.0	49.0	61.0	1.0	60.0	63.0	2.0	48.0	NVA

Table C.1: Cross Creek Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
72	26	24.5	11.0	9.0	25.0	20.0	32.0	5.0	45.0	49.0	NVA
73	26	12.4	13.0	16.0	5.0	16.0	11.0	12.0	17.0	9.0	NVA
75	27	8.1	9.0	1.0	9.0	8.0	10.0	14.0	1.0	13.0	NVA
76	27	21.6	23.0	12.0	29.0	8.0	1.0	4.0	70.0	26.0	NVA
77	27	34.4	48.0	50.0	5.0	38.0	44.0	11.0	33.0	46.0	NVA
78	27	23.5	27.0	29.0	4.0	26.0	27.0	12.0	21.0	42.0	NVA
79	27	24.4	30.0	17.0	1.0	27.0	8.0	43.0	26.0	43.0	NVA
81	27	7.3	12.0	2.0	15.0	5.0	4.0	6.0	10.0	4.0	NVA
82	27	33.9	33.0	38.0	42.0	40.0	18.0	40.0	39.0	21.0	NVA
83	28	41.5	62.0	47.0	58.0	31.0	52.0	41.0	1.0	40.0	NVA
84	28	24.4	38.0	2.0	35.0	23.0	17.0	20.0	36.0	24.0	NVA
87	28	5.9	0.0	5.0	9.0	10.0	4.0	8.0	11.0	0.0	NVA
92	29	34.8	26.0	40.0	44.0	57.0	25.0	12.0	20.0	54.0	NVA
94	29	14.9	9.0	12.0	27.0	12.0	2.0	17.0	23.0	17.0	NVA
95	29	31.1	39.0	21.0	7.0	8.0	59.0	60.0	27.0	28.0	NVA
96	29	33.3	29.0	47.0	55.0	17.0	52.0	39.0	5.0	22.0	NVA
97	29	33.3	28.0	14.0	6.0	30.0	44.0	51.0	56.0	37.0	NVA
100	29	40.0	71.0	12.0	60.0	24.0	40.0	35.0	55.0	23.0	NVA
103	30	20.0	36.0	19.0	2.0	22.0	37.0	0.0	28.0	16.0	NVA
105	30	15.6	17.0	19.0	20.0	6.0	25.0	12.0	11.0	15.0	NVA
106	30	6.6	10.0	4.0	8.0	6.0	5.0	5.0	3.0	12.0	NVA
107	30	4.3	11.0	3.0	4.0	6.0	3.0	2.0	0.0	5.0	NVA
108	31	20.8	16.0	17.0	20.0	22.0	14.0	15.0	45.0	17.0	NVA
109	31	2.9	5.0	3.0	4.0	3.0	1.0	5.0	0.0	2.0	NVA
110	31	34.5	14.0	59.0	54.0	8.0	46.0	46.0	26.0	23.0	NVA
112	31	33.1	29.0	18.0	1.0	18.0	62.0	46.0	36.0	55.0	NVA
113	31	29.4	29.0	20.0	32.0	47.0	36.0	31.0	31.0	9.0	NVA
114	31	6.9	8.0	1.0	2.0	15.0	5.0	4.0	6.0	14.0	NVA
115	32	2.1	2.0	1.0	4.0	3.0	1.0	3.0	1.0	2.0	NVA
116	32	19.4	23.0	15.0	29.0	9.0	28.0	7.0	21.0	23.0	NVA
117	32	30.8	23.0	38.0	6.0	46.0	51.0	7.0	73.0	2.0	NVA
118	32	30.0	0.0	29.0	15.0	15.0	65.0	56.0	21.0	39.0	NVA
121	32	19.4	6.0	10.0	31.0	29.0	30.0	12.0	11.0	26.0	NVA
124	33	18.5	12.0	3.0	32.0	10.0	8.0	40.0	23.0	20.0	NVA
125	33	27.0	26.0	46.0	41.0	38.0	26.0	23.0	10.0	6.0	NVA
128	34	33.6	19.0	23.0	43.0	42.0	34.0	44.0	1.0	63.0	NVA
130	34	21.6	25.0	39.0	36.0	19.0	4.0	12.0	17.0	21.0	NVA
131	34	41.6	6.0	60.0	41.0	80.0	48.0	4.0	71.0	23.0	NVA
132	34	19.4	9.0	26.0	23.0	19.0	14.0	28.0	21.0	15.0	NVA
133	34	3.9	2.0	3.0	9.0	8.0	3.0	3.0	3.0	0.0	NVA
134	35	8.4	0.0	8.0	9.0	12.0	5.0	12.0	9.0	12.0	NVA
135	35	42.0	37.0	82.0	44.0	21.0	12.0	71.0	61.0	8.0	NVA
136	35	25.1	12.0	47.0	42.0	46.0	1.0	18.0	35.0	0.0	NVA
137	35	48.5	74.0	48.0	8.0	64.0	59.0	46.0	10.0	79.0	NVA
138	35	19.9	5.0	17.0	36.0	26.0	18.0	9.0	35.0	13.0	NVA
139	36	28.4	33.0	13.0	26.0	34.0	20.0	16.0	35.0	50.0	NVA
140	36	4.9	2.0	7.0	7.0	1.0	9.0	7.0	0.0	6.0	NVA
143	36	7.3	5.0	11.0	6.0	11.0	11.0	6.0	4.0	4.0	NVA
144	37	44.4	24.0	51.0	89.0	23.0	82.0	28.0	14.0	44.0	NVA
146	37	17.4	1.0	9.0	3.0	45.0	38.0	31.0	5.0	7.0	NVA
147	37	14.4	13.0	21.0	18.0	5.0	7.0	11.0	25.0	15.0	NVA
148	37	35.5	59.0	8.0	25.0	64.0	68.0	3.0	12.0	45.0	NVA
149	38	38.8	12.0	53.0	42.0	49.0	42.0	62.0	24.0	26.0	NVA
150	38	14.3	7.0	27.0	25.0	11.0	11.0	18.0	6.0	9.0	NVA
151	38	2.3	1.0	2.0	4.0	1.0	1.0	1.0	4.0	4.0	NVA
152	38	21.6	16.0	10.0	10.0	38.0	36.0	38.0	3.0	22.0	NVA
154	39	2.8	6.0	1.0	3.0	1.0	2.0	0.0	4.0	5.0	NVA
155	39	10.9	19.0	1.0	1.0	19.0	12.0	4.0	19.0	12.0	NVA
157	39	33.4	40.0	20.0	44.0	37.0	30.0	35.0	43.0	18.0	NVA
158	40	16.3	13.0	17.0	9.0	8.0	28.0	23.0	26.0	6.0	NVA

Table C.1: Cross Creek Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
161	40	53.6	26.0	84.0	0.0	76.0	9.0	64.0	84.0	86.0	NVA
162	41	2.8	3.0	2.0	6.0	3.0	2.0	1.0	4.0	1.0	NVA
165	41	7.9	3.0	15.0	1.0	8.0	6.0	9.0	17.0	4.0	NVA
167	42	14.0	6.0	13.0	7.0	13.0	19.0	12.0	20.0	22.0	NVA
168	42	5.0	11.0	1.0	7.0	2.0	10.0	4.0	2.0	3.0	NVA
169	42	9.8	4.0	21.0	1.0	14.0	18.0	1.0	10.0	9.0	NVA
170	43	8.4	3.0	7.0	14.0	10.0	1.0	3.0	6.0	23.0	NVA
171	43	2.5	4.0	3.0	3.0	2.0	0.0	4.0	2.0	2.0	NVA
173	44	5.5	3.0	9.0	1.0	8.0	3.0	4.0	8.0	8.0	NVA
174	44	27.3	31.0	44.0	21.0	19.0	42.0	44.0	5.0	12.0	NVA
175	44	36.5	6.0	13.0	55.0	30.0	1.0	84.0	28.0	75.0	NVA
177	45	21.4	10.0	5.0	1.0	26.0	27.0	37.0	27.0	38.0	NVA
178	45	42.0	51.0	38.0	60.0	48.0	49.0	28.0	10.0	52.0	NVA
180	46	17.8	19.0	32.0	33.0	4.0	10.0	1.0	31.0	12.0	NVA
181	46	3.8	4.0	4.0	5.0	1.0	2.0	3.0	6.0	5.0	NVA
182	46	37.9	14.0	41.0	27.0	37.0	37.0	59.0	45.0	43.0	NVA
183	47	2.5	1.0	3.0	2.0	1.0	4.0	2.0	5.0	2.0	NVA
184	47	71.0	90.0	62.0	89.0	21.0	32.0	84.0	83.0	107.0	NVA
185	47	20.5	4.0	1.0	18.0	21.0	32.0	34.0	30.0	24.0	NVA
186	48	64.1	71.0	23.0	63.0	33.0	84.0	75.0	82.0	82.0	NVA
188	49	28.0	15.0	42.0	63.0	14.0	28.0	36.0	23.0	3.0	NVA
189	49	54.6	67.0	49.0	17.0	104.0	63.0	9.0	106.0	22.0	NVA
190	49	61.5	72.0	75.0	64.0	21.0	76.0	73.0	56.0	55.0	NVA
191	50	64.4	116.0	27.0	64.0	55.0	32.0	21.0	100.0	100.0	NVA
192	50	35.1	74.0	4.0	40.0	5.0	72.0	29.0	48.0	9.0	NVA
196	52	50.6	80.0	48.0	86.0	29.0	20.0	14.0	36.0	92.0	NVA
197	52	38.4	15.0	45.0	24.0	37.0	26.0	58.0	57.0	45.0	NVA
199	53	30.6	8.0	18.0	21.0	29.0	6.0	35.0	75.0	53.0	NVA
201	54	34.0	61.0	16.0	50.0	17.0	20.0	54.0	29.0	25.0	NVA
205	56	12.4	15.0	3.0	17.0	2.0	31.0	16.0	8.0	7.0	NVA
206	56	80.8	18.0	52.0	118.0	146.0	82.0	66.0	127.0	37.0	NVA
207	57	48.1	42.0	34.0	51.0	64.0	73.0	37.0	42.0	42.0	NVA
208	57	76.9	20.0	129.0	95.0	36.0	113.0	85.0	12.0	125.0	NVA
210	59	33.1	54.0	44.0	24.0	30.0	8.0	43.0	59.0	3.0	NVA
211	59	28.1	38.0	16.0	32.0	9.0	33.0	16.0	34.0	47.0	NVA
212	60	49.1	66.0	60.0	31.0	61.0	32.0	66.0	12.0	65.0	NVA
213	60	28.6	56.0	40.0	8.0	41.0	10.0	10.0	30.0	34.0	NVA
214	61	67.4	120.0	118.0	94.0	28.0	93.0	13.0	63.0	10.0	NVA
215	61	4.0	3.0	1.0	5.0	2.0	5.0	6.0	4.0	6.0	NVA
217	63	67.5	80.0	39.0	46.0	61.0	93.0	92.0	48.0	81.0	NVA
218	63	72.6	86.0	15.0	55.0	97.0	93.0	84.0	97.0	54.0	NVA
219	64	3.3	0.0	4.0	3.0	2.0	2.0	5.0	3.0	7.0	NVA
220	65	43.5	63.0	26.0	36.0	31.0	49.0	58.0	47.0	38.0	NVA
221	65	30.3	16.0	30.0	34.0	65.0	35.0	40.0	1.0	21.0	NVA
224	68	14.6	15.0	11.0	22.0	4.0	16.0	25.0	11.0	13.0	NVA
225	68	21.5	36.0	29.0	25.0	15.0	4.0	8.0	24.0	31.0	NVA
226	69	91.9	169.0	51.0	90.0	112.0	87.0	38.0	56.0	132.0	NVA
228	71	27.8	25.0	18.0	33.0	6.0	13.0	53.0	31.0	43.0	NVA
229	72	58.6	99.0	14.0	32.0	31.0	53.0	112.0	100.0	28.0	NVA
230	73	74.6	65.0	147.0	66.0	119.0	78.0	17.0	78.0	27.0	NVA
232	74	100.0	73.0	99.0	192.0	32.0	98.0	176.0	70.0	60.0	NVA
233	75	25.6	27.0	37.0	18.0	22.0	41.0	29.0	23.0	8.0	NVA
234	76	69.6	132.0	28.0	89.0	91.0	84.0	81.0	28.0	24.0	NVA
235	77	71.9	6.0	19.0	83.0	59.0	124.0	118.0	86.0	80.0	NVA
236	78	51.9	82.0	70.0	77.0	75.0	41.0	37.0	27.0	6.0	NVA
237	79	32.9	34.0	35.0	48.0	35.0	27.0	31.0	28.0	25.0	NVA
238	80	6.0	6.0	2.0	6.0	5.0	11.0	2.0	7.0	9.0	NVA
239	82	98.0	64.0	90.0	83.0	160.0	115.0	42.0	141.0	89.0	NVA
241	84	51.1	85.0	57.0	39.0	103.0	68.0	4.0	50.0	3.0	NVA
243	86	30.6	35.0	1.0	59.0	24.0	11.0	30.0	44.0	41.0	NVA

Table C.1: Cross Creek Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
244	88	153.1	198.0	117.0	212.0	171.0	216.0	76.0	169.0	66.0	NVA
245	89	104.8	77.0	140.0	119.0	113.0	99.0	71.0	87.0	132.0	NVA
247	92	56.9	46.0	72.0	17.0	81.0	66.0	73.0	82.0	18.0	NVA
248	94	51.0	85.0	97.0	53.0	7.0	58.0	10.0	69.0	29.0	NVA
249	95	32.1	34.0	3.0	43.0	21.0	32.0	14.0	64.0	46.0	NVA
250	97	126.5	150.0	25.0	201.0	171.0	130.0	31.0	151.0	153.0	NVA
251	98	85.4	1.0	132.0	67.0	110.0	31.0	129.0	77.0	136.0	NVA
252	100	63.6	139.0	46.0	13.0	28.0	117.0	51.0	4.0	111.0	NVA
254	104	55.3	28.0	6.0	82.0	22.0	78.0	67.0	81.0	78.0	NVA
255	106	11.0	19.0	2.0	3.0	12.0	7.0	15.0	18.0	12.0	NVA
256	108	130.6	116.0	177.0	140.0	156.0	181.0	95.0	66.0	114.0	NVA
257	110	119.4	221.0	36.0	39.0	141.0	212.0	96.0	101.0	109.0	NVA
259	114	54.9	52.0	71.0	9.0	57.0	48.0	69.0	57.0	76.0	NVA
260	117	37.8	10.0	51.0	38.0	53.0	36.0	46.0	14.0	54.0	NVA
261	119	83.1	74.0	103.0	74.0	131.0	67.0	31.0	30.0	155.0	NVA
262	122	48.9	79.0	41.0	23.0	70.0	49.0	47.0	54.0	28.0	NVA
264	128	58.3	48.0	22.0	44.0	104.0	99.0	41.0	13.0	95.0	NVA
265	131	42.5	36.0	43.0	47.0	48.0	59.0	50.0	41.0	16.0	NVA
266	134	48.0	28.0	17.0	23.0	71.0	74.0	51.0	29.0	91.0	NVA
267	138	131.8	270.0	109.0	70.0	25.0	72.0	5.0	189.0	314.0	NVA
268	141	188.4	310.0	337.0	89.0	179.0	50.0	241.0	103.0	198.0	NVA
269	145	198.0	202.0	342.0	104.0	39.0	271.0	179.0	162.0	285.0	NVA
270	149	4.4	6.0	3.0	4.0	7.0	1.0	3.0	6.0	5.0	NVA
271	154	174.4	223.0	315.0	235.0	133.0	55.0	256.0	66.0	112.0	NVA
272	158	195.1	0.0	121.0	176.0	269.0	326.0	272.0	53.0	344.0	NVA
273	163	49.9	36.0	42.0	70.0	20.0	68.0	74.0	69.0	20.0	NVA
274	168	57.3	5.0	52.0	81.0	45.0	68.0	50.0	65.0	92.0	NVA
275	174	128.1	140.0	79.0	85.0	131.0	140.0	168.0	100.0	182.0	NVA
276	180	212.6	406.0	37.0	86.0	228.0	27.0	376.0	319.0	222.0	NVA
277	187	221.1	210.0	256.0	46.0	196.0	225.0	269.0	312.0	255.0	NVA
278	194	71.0	123.0	180.0	59.0	26.0	51.0	0.0	68.0	61.0	NVA
279	202	17.1	8.0	30.0	13.0	10.0	4.0	26.0	15.0	31.0	NVA
280	210	144.6	203.0	197.0	26.0	43.0	140.0	199.0	122.0	227.0	NVA
281	219	48.6	27.0	47.0	49.0	103.0	44.0	13.0	81.0	25.0	NVA
284	253	278.8	374.0	164.0	48.0	313.0	474.0	283.0	99.0	475.0	NVA
289	346	385.1	764.0	346.0	435.0	33.0	506.0	789.0	124.0	84.0	NVA
292	449	276.4	90.0	157.0	463.0	81.0	439.0	277.0	677.0	27.0	NVA
293	500	66.8	128.0	52.0	70.0	2.0	131.0	10.0	87.0	54.0	NVA
297	968	218.0	397.0	450.0	3.0	88.0	1.0	317.0	324.0	164.0	NVA
299	2060	2122.3	2209.0	2104.0	1059.0	1158.0	2024.0	2955.0	2511.0	2958.0	NVA

Table C.2: Cross Creek Example Data – Separate VA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
4	21	5.0	3.0	6.0	6.0	5.0	5.0	6.0	3.0	6.0	HY - VA
5	21	16.5	15.0	18.0	16.0	14.0	7.0	22.0	18.0	22.0	HY - VA
13	22	17.1	6.0	15.0	18.0	9.0	24.0	19.0	22.0	24.0	HY - VA
20	22	4.3	1.0	6.0	4.0	6.0	6.0	3.0	2.0	6.0	HY - VA
23	22	8.6	2.0	9.0	4.0	11.0	1.0	18.0	6.0	18.0	HY - VA
24	22	20.6	13.0	39.0	2.0	24.0	34.0	12.0	2.0	39.0	HY - VA
25	22	13.4	15.0	0.0	7.0	13.0	20.0	20.0	12.0	20.0	HY - VA
27	23	24.4	12.0	28.0	33.0	11.0	34.0	23.0	15.0	39.0	HY - VA
28	23	4.0	1.0	3.0	3.0	6.0	5.0	2.0	6.0	6.0	HY - VA
32	23	24.3	41.0	32.0	5.0	16.0	11.0	20.0	28.0	41.0	HY - VA
33	23	20.8	13.0	6.0	3.0	1.0	36.0	37.0	33.0	37.0	HY - VA
39	23	22.8	0.0	12.0	36.0	20.0	21.0	15.0	39.0	39.0	HY - VA
42	24	17.3	21.0	20.0	0.0	30.0	23.0	12.0	2.0	30.0	HY - VA
48	24	6.4	9.0	3.0	4.0	4.0	7.0	8.0	7.0	9.0	HY - VA

Table C.2: Cross Creek Example Data – Separate VA. *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
53	25	21.3	30.0	30.0	0.0	27.0	24.0	23.0	6.0	30.0	HY - VA
54	25	19.5	24.0	13.0	23.0	1.0	25.0	18.0	26.0	26.0	HY - VA
57	25	17.0	37.0	13.0	3.0	14.0	11.0	12.0	9.0	37.0	HY - VA
60	25	11.1	3.0	1.0	23.0	10.0	6.0	10.0	13.0	23.0	HY - VA
63	25	18.0	7.0	30.0	12.0	13.0	27.0	12.0	13.0	30.0	HY - VA
64	26	5.8	3.0	4.0	9.0	3.0	8.0	7.0	3.0	9.0	HY - VA
65	26	11.6	7.0	27.0	11.0	14.0	4.0	2.0	1.0	27.0	HY - VA
68	26	14.6	17.0	12.0	21.0	6.0	12.0	16.0	12.0	21.0	HY - VA
69	26	8.8	3.0	9.0	12.0	11.0	7.0	7.0	9.0	12.0	HY - VA
71	26	25.5	38.0	26.0	19.0	14.0	3.0	30.0	36.0	38.0	HY - VA
74	27	29.0	9.0	24.0	42.0	36.0	35.0	33.0	11.0	42.0	HY - VA
80	27	22.0	26.0	27.0	39.0	14.0	1.0	29.0	1.0	39.0	HY - VA
85	28	11.3	1.0	18.0	9.0	1.0	23.0	3.0	12.0	23.0	HY - VA
86	28	24.0	22.0	12.0	39.0	23.0	30.0	9.0	18.0	39.0	HY - VA
88	28	13.8	6.0	24.0	1.0	3.0	6.0	6.0	32.0	32.0	HY - VA
89	28	2.1	3.0	0.0	1.0	1.0	1.0	3.0	2.0	6.0	HY - VA
90	28	18.3	20.0	8.0	3.0	27.0	32.0	15.0	9.0	32.0	HY - VA
91	28	26.8	3.0	34.0	36.0	44.0	2.0	27.0	24.0	44.0	HY - VA
93	29	27.1	30.0	29.0	33.0	3.0	16.0	36.0	34.0	36.0	HY - VA
98	29	7.9	11.0	10.0	5.0	0.0	14.0	9.0	0.0	14.0	HY - VA
99	29	13.5	17.0	1.0	21.0	6.0	11.0	6.0	23.0	23.0	HY - VA
101	30	17.5	14.0	23.0	2.0	30.0	30.0	3.0	8.0	30.0	HY - VA
102	30	20.3	13.0	24.0	24.0	12.0	18.0	17.0	27.0	27.0	HY - VA
104	30	18.3	21.0	3.0	15.0	25.0	15.0	24.0	18.0	25.0	HY - VA
111	31	19.6	11.0	6.0	32.0	9.0	22.0	15.0	30.0	32.0	HY - VA
119	32	9.0	3.0	18.0	1.0	9.0	4.0	6.0	13.0	18.0	HY - VA
120	32	26.8	16.0	30.0	15.0	6.0	31.0	39.0	38.0	39.0	HY - VA
122	33	19.9	1.0	35.0	5.0	12.0	42.0	7.0	10.0	47.0	HY - VA
123	33	23.9	27.0	2.0	9.0	15.0	58.0	7.0	15.0	58.0	HY - VA
126	33	21.4	33.0	34.0	16.0	25.0	8.0	15.0	3.0	37.0	HY - VA
127	33	4.3	3.0	8.0	1.0	3.0	1.0	7.0	3.0	8.0	HY - VA
129	34	13.4	17.0	6.0	8.0	21.0	12.0	13.0	9.0	21.0	HY - VA
141	36	2.8	3.0	4.0	0.0	3.0	3.0	3.0	2.0	4.0	HY - VA
142	36	37.5	30.0	27.0	30.0	26.0	42.0	63.0	19.0	63.0	HY - VA
145	37	8.5	5.0	17.0	3.0	0.0	9.0	2.0	15.0	17.0	HY - VA
153	38	12.1	14.0	8.0	3.0	5.0	6.0	7.0	27.0	27.0	HY - VA
156	39	30.5	20.0	40.0	48.0	15.0	48.0	6.0	19.0	48.0	HY - VA
159	40	4.0	6.0	6.0	1.0	6.0	4.0	3.0	0.0	6.0	HY - VA
160	40	28.5	57.0	18.0	20.0	7.0	37.0	20.0	12.0	57.0	HY - VA
163	41	26.1	33.0	31.0	21.0	12.0	25.0	24.0	30.0	33.0	HY - VA
164	41	6.6	3.0	12.0	12.0	5.0	2.0	6.0	1.0	12.0	HY - VA
166	42	16.9	10.0	15.0	13.0	24.0	20.0	6.0	23.0	24.0	HY - VA
172	43	11.1	9.0	17.0	9.0	4.0	14.0	6.0	13.0	17.0	HY - VA
176	44	41.6	52.0	8.0	15.0	27.0	58.0	57.0	57.0	59.0	HY - VA
179	45	20.3	35.0	1.0	36.0	9.0	6.0	10.0	26.0	39.0	HY - VA
187	48	42.8	72.0	11.0	65.0	43.0	1.0	39.0	39.0	72.0	HY - VA
193	50	21.6	35.0	28.0	30.0	6.0	12.0	20.0	7.0	35.0	HY - VA
194	51	21.6	25.0	21.0	16.0	12.0	21.0	26.0	14.0	38.0	HY - VA
195	51	2.8	3.0	0.0	2.0	3.0	4.0	3.0	3.0	4.0	HY - VA
198	53	61.3	57.0	71.0	29.0	79.0	24.0	73.0	78.0	79.0	HY - VA
200	53	41.5	62.0	27.0	60.0	6.0	6.0	53.0	56.0	62.0	HY - VA
202	54	17.9	29.0	16.0	21.0	27.0	3.0	16.0	2.0	29.0	HY - VA
203	55	34.9	16.0	53.0	48.0	3.0	15.0	54.0	36.0	54.0	HY - VA
204	55	67.1	62.0	57.0	44.0	75.0	76.0	86.0	51.0	86.0	HY - VA
209	58	60.8	61.0	96.0	27.0	7.0	96.0	76.0	27.0	96.0	HY - VA
216	62	54.5	81.0	10.0	1.0	99.0	70.0	66.0	10.0	99.0	HY - VA
222	66	25.9	38.0	31.0	3.0	34.0	2.0	29.0	32.0	38.0	HY - VA
223	67	24.8	10.0	33.0	35.0	13.0	13.0	30.0	29.0	35.0	HY - VA
227	70	40.5	45.0	39.0	21.0	40.0	55.0	24.0	45.0	55.0	HY - VA
231	73	34.9	13.0	51.0	13.0	21.0	36.0	61.0	23.0	61.0	HY - VA

Table C.2: Cross Creek Example Data – Separate VA. *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
240	83	31.5	41.0	33.0	9.0	36.0	61.0	3.0	8.0	61.0	HY - VA
242	85	21.5	19.0	35.0	7.0	21.0	28.0	18.0	9.0	35.0	HY - VA
246	91	2.6	0.0	2.0	3.0	3.0	2.0	4.0	3.0	4.0	HY - VA
253	102	108.1	33.0	159.0	73.0	128.0	60.0	90.0	161.0	161.0	HY - VA
258	112	110.8	72.0	10.0	162.0	192.0	126.0	89.0	43.0	192.0	HY - VA
263	125	91.4	93.0	21.0	65.0	116.0	152.0	36.0	74.0	174.0	HY - VA
282	230	228.8	303.0	276.0	192.0	99.0	24.0	140.0	398.0	398.0	HY - VA
283	241	25.5	51.0	5.0	30.0	10.0	3.0	26.0	28.0	51.0	HY - VA
285	267	113.0	141.0	57.0	122.0	74.0	144.0	78.0	144.0	144.0	HY - VA
286	283	274.1	216.0	365.0	288.0	312.0	24.0	130.0	429.0	429.0	HY - VA
287	301	95.5	144.0	36.0	135.0	57.0	148.0	0.0	96.0	148.0	HY - VA
288	322	90.0	102.0	25.0	95.0	39.0	133.0	66.0	127.0	133.0	HY - VA
290	374	61.1	48.0	47.0	58.0	78.0	39.0	49.0	85.0	85.0	HY - VA
291	408	156.6	246.0	201.0	129.0	142.0	132.0	18.0	139.0	246.0	HY - VA
294	566	286.9	1.0	23.0	300.0	346.0	594.0	347.0	90.0	594.0	HY - VA
295	654	627.8	504.0	924.0	543.0	683.0	127.0	825.0	492.0	924.0	HY - VA
296	778	375.9	108.0	198.0	105.0	365.0	554.0	630.0	417.0	630.0	HY - VA
298	1300	566.9	19.0	996.0	810.0	430.0	102.0	927.0	255.0	996.0	HY - VA
300	20365	11155.1	11624.0	819.0	18424.0	6691.0	15686.0	16454.0	1119.0	18424.0	HY - VA

Appendix D

Cross Creek Example Tradeoff Results

In this appendix we present the tradeoff results for the Cross Creek example. The first column represents the layout. A number in the first column represents the SKU which has been moved to the non-hybrid area. The column labeled "Total Dist/Tour" represents the distance per tour for the given layout. The column labeled "Retrievals/Hour per Operator" represents the number of retrievals per hour per operator for the given layout. The column labeled "Area" represents the area required for the given layout. The column labeled "Labor Cost" represents the total cost of labor for the given layout. The column labeled "WH Cost" represents the total cost of warehouse space for the given layout. The column labeled "Total Cost" represents the total cost of the given layout. The column labeled "Change" represents the change in cost from the previous layout.

Table D.1: Cross Creek Example Tradeoff Results.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
Combined	1544.71	9.32	32760	$156,438	$163,800	$320,238	
Separate	1314.50	10.95	44352	$133,123	$221,760	$354,883	
All in Hybrid	1497.83	9.61	35840	$151,690	$179,200	$330,890	
246	1497.57	9.62	35840	$151,664	$179,200	$330,864	$27
195	1497.42	9.62	35840	$151,648	$179,200	$330,848	$15
141	1497.31	9.62	35840	$151,638	$179,200	$330,838	$11
89	1497.23	9.62	35840	$151,629	$179,200	$330,829	$8
159	1497.11	9.62	35840	$151,617	$179,200	$330,817	$12
283	1496.41	9.62	35840	$151,546	$179,200	$330,746	$72
127	1496.31	9.62	35840	$151,536	$179,200	$330,736	$10
164	1496.19	9.62	35840	$151,524	$179,200	$330,724	$12
20	1496.12	9.62	35840	$151,517	$179,200	$330,717	$7
28	1496.06	9.63	35840	$151,510	$179,200	$330,710	$7
290	1494.96	9.63	35840	$151,399	$179,200	$330,599	$111
145	1494.85	9.63	35840	$151,388	$179,200	$330,588	$11
64	1494.78	9.63	35840	$151,381	$179,200	$330,581	$8
4	1494.72	9.63	35840	$151,375	$179,200	$330,575	$6
172	1494.59	9.63	35840	$151,362	$179,200	$330,562	$13
48	1494.52	9.64	35840	$151,355	$179,200	$330,555	$7
242	1494.27	9.64	35840	$151,329	$179,200	$330,529	$25
119	1494.17	9.64	35840	$151,320	$179,200	$330,520	$10
98	1494.09	9.64	35840	$151,311	$179,200	$330,511	$9
69	1494.01	9.64	35840	$151,303	$179,200	$330,503	$8
288	1493.07	9.64	35840	$151,208	$179,200	$330,408	$96
202	1492.91	9.65	35840	$151,191	$179,200	$330,391	$16
153	1492.80	9.65	35840	$151,180	$179,200	$330,380	$11
287	1491.91	9.65	35840	$151,091	$179,200	$330,291	$89
223	1491.72	9.65	35840	$151,071	$179,200	$330,271	$20
129	1491.62	9.65	35840	$151,061	$179,200	$330,261	$10
85	1491.54	9.65	35840	$151,052	$179,200	$330,252	$8
65	1491.46	9.65	35840	$151,045	$179,200	$330,245	$8
23	1491.39	9.66	35840	$151,038	$179,200	$330,238	$7
193	1491.25	9.66	35840	$151,023	$179,200	$330,223	$15
291	1490.05	9.66	35840	$150,902	$179,200	**$330,102**	$121
240	1489.81	9.67	36400	$150,878	$182,000	$332,878	-$2,775
60	1489.73	9.67	36400	$150,870	$182,000	$332,870	$7
166	1489.61	9.67	36400	$150,858	$182,000	$332,858	$12
222	1489.42	9.67	36400	$150,838	$182,000	$332,838	$20
285	1488.63	9.67	36400	$150,759	$182,000	$332,759	$79
99	1488.55	9.67	36400	$150,750	$182,000	$332,750	$9
296	1486.27	9.69	36400	$150,519	$182,000	$332,519	$231
88	1486.18	9.69	36400	$150,510	$182,000	$332,510	$8
298	1482.37	9.71	36960	$150,124	$184,800	$334,924	-$2,414
194	1482.22	9.72	36960	$150,109	$184,800	$334,909	$15
179	1482.09	9.72	36960	$150,096	$184,800	$334,896	$13
231	1481.87	9.72	36960	$150,074	$184,800	$334,874	$22
294	1480.21	9.73	36960	$149,906	$184,800	$334,706	$168
68	1480.14	9.73	36960	$149,898	$184,800	$334,698	$8
227	1479.93	9.73	36960	$149,877	$184,800	$334,677	$21
300	1420.19	10.14	43120	$143,827	$215,600	$359,427	-$24,750
203	1420.03	10.14	43120	$143,811	$215,600	$359,411	$16
25	1419.96	10.14	43120	$143,804	$215,600	$359,404	$7
111	1419.87	10.14	43120	$143,795	$215,600	$359,395	$9
101	1419.79	10.14	43120	$143,786	$215,600	$359,386	$9
163	1419.67	10.14	43120	$143,774	$215,600	$359,374	$12
104	1419.58	10.14	43120	$143,765	$215,600	$359,365	$9
102	1419.49	10.14	43120	$143,756	$215,600	$359,356	$9

Table D.1: Cross Creek Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change Change
57	1419.42	10.14	43120	$143,749	$215,600	$359,349	$7
122	1419.32	10.15	43120	$143,739	$215,600	$359,339	$10
160	1419.21	10.15	43120	$143,727	$215,600	$359,327	$12
123	1419.11	10.15	43120	$143,718	$215,600	$359,318	$10
90	1419.03	10.15	43120	$143,709	$215,600	$359,309	$8
63	1418.95	10.15	43120	$143,702	$215,600	$359,302	$8
126	1418.85	10.15	43120	$143,692	$215,600	$359,292	$10
200	1418.70	10.15	43120	$143,676	$215,600	$359,276	$16
13	1418.63	10.15	43120	$143,670	$215,600	$359,270	$6
42	1418.56	10.15	43120	$143,663	$215,600	$359,263	$7
156	1418.45	10.15	43120	$143,651	$215,600	$359,251	$12
80	1418.37	10.15	43120	$143,643	$215,600	$359,243	$8
86	1418.29	10.15	43120	$143,635	$215,600	$359,235	$8
5	1418.23	10.15	43120	$143,628	$215,600	$359,228	$6
33	1418.16	10.15	43120	$143,621	$215,600	$359,221	$7
120	1418.06	10.15	43120	$143,612	$215,600	$359,212	$10
263	1417.70	10.16	43120	$143,575	$215,600	$359,175	$37
54	1417.63	10.16	43120	$143,567	$215,600	$359,167	$7
216	1417.44	10.16	43120	$143,549	$215,600	$359,149	$18
187	1417.30	10.16	43120	$143,535	$215,600	$359,135	$14
93	1417.22	10.16	43120	$143,526	$215,600	$359,126	$9
53	1417.15	10.16	43120	$143,519	$215,600	$359,119	$7
295	1415.23	10.18	43120	$143,325	$215,600	$358,925	$194
282	1414.55	10.18	43120	$143,256	$215,600	$358,856	$68
91	1414.47	10.18	43120	$143,248	$215,600	$358,848	$8
71	1414.39	10.18	43120	$143,240	$215,600	$358,840	$8
39	1414.33	10.18	43120	$143,233	$215,600	$358,833	$7
24	1414.26	10.18	43120	$143,227	$215,600	$358,827	$7
258	1413.93	10.18	43120	$143,193	$215,600	$358,793	$33
176	1413.80	10.19	43120	$143,180	$215,600	$358,780	$13
209	1413.63	10.19	43120	$143,163	$215,600	$358,763	$17
142	1413.52	10.19	43120	$143,152	$215,600	$358,752	$11
286	1412.69	10.19	43120	$143,068	$215,600	$358,668	$84
253	1412.39	10.20	43120	$143,038	$215,600	$358,638	$30
32	1412.33	10.20	43120	$143,031	$215,600	$358,631	$7
74	1412.25	10.20	43120	$143,023	$215,600	$358,623	$8
27	1412.18	10.20	43120	$143,016	$215,600	$358,616	$7
198	1412.03	10.20	43120	$143,001	$215,600	$358,601	$16
204	1411.87	10.20	43120	$142,984	$215,600	$358,584	$16

Appendix E

Equal–SKU Split Example Reserve Data – Combined

In this appendix we present the combined data for the reserve department of the equal–SKU split example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Avg. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table E.1: Equal–SKU Split Example Reserve Data – Combined.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
1	21	21.1	20.0	7.0	19.0	32.0	36.0	50.0	4.0	1.0	NVA
2	21	6.9	2.0	11.0	8.0	11.0	8.0	3.0	8.0	4.0	VA
3	21	27.3	32.0	40.0	3.0	42.0	0.0	29.0	41.0	31.0	HY
4	21	5.6	5.0	3.0	7.0	8.0	6.0	6.0	7.0	3.0	NVA
5	21	20.0	17.0	19.0	23.0	21.0	18.0	9.0	29.0	24.0	VA
6	21	4.6	5.0	4.0	7.0	5.0	3.0	2.0	6.0	5.0	NVA
7	21	16.8	25.0	28.0	29.0	8.0	3.0	2.0	25.0	14.0	NVA
8	21	8.0	8.0	4.0	12.0	1.0	7.0	10.0	11.0	11.0	VA
9	21	15.5	2.0	7.0	29.0	18.0	10.0	6.0	26.0	26.0	NVA
10	21	4.1	4.0	7.0	4.0	3.0	3.0	2.0	6.0	4.0	VA
11	21	2.4	0.0	0.0	4.0	4.0	1.0	4.0	3.0	3.0	VA
12	22	4.9	5.0	8.0	5.0	10.0	2.0	2.0	5.0	2.0	VA
13	22	20.0	14.0	8.0	19.0	23.0	11.0	31.0	25.0	29.0	VA
14	22	7.0	13.0	10.0	13.0	2.0	4.0	8.0	5.0	1.0	NVA

Table E.1: Equal–SKU Split Example Reserve Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
15	22	5.3	2.0	9.0	4.0	4.0	10.0	7.0	0.0	6.0	NVA
16	22	29.8	34.0	45.0	40.0	17.0	16.0	34.0	40.0	12.0	NVA
17	22	17.8	4.0	26.0	32.0	1.0	26.0	2.0	26.0	25.0	HY
18	22	3.9	5.0	6.0	6.0	4.0	2.0	3.0	4.0	1.0	NVA
19	22	34.8	47.0	36.0	34.0	44.0	29.0	20.0	47.0	21.0	NVA
20	22	4.4	0.0	1.0	7.0	5.0	8.0	8.0	4.0	2.0	VA
21	22	10.0	14.0	12.0	6.0	6.0	11.0	4.0	7.0	20.0	NVA
22	22	29.8	9.0	11.0	44.0	32.0	41.0	28.0	35.0	38.0	HY
23	22	9.9	15.0	2.0	11.0	5.0	14.0	1.0	23.0	8.0	VA
24	22	26.3	45.0	17.0	51.0	2.0	32.0	45.0	16.0	2.0	HY
25	22	16.0	15.0	20.0	0.0	9.0	17.0	26.0	26.0	15.0	NVA
26	23	12.5	15.0	3.0	20.0	6.0	10.0	12.0	22.0	12.0	NVA
27	23	31.9	51.0	15.0	37.0	44.0	14.0	45.0	30.0	19.0	HY
28	23	4.6	6.0	1.0	3.0	4.0	8.0	6.0	2.0	7.0	NVA
29	23	12.5	14.0	17.0	6.0	17.0	17.0	15.0	12.0	2.0	HY
30	23	2.8	3.0	1.0	3.0	3.0	5.0	5.0	2.0	0.0	HY
31	23	28.1	20.0	21.0	31.0	0.0	25.0	43.0	50.0	35.0	VA
32	23	31.0	48.0	54.0	42.0	6.0	21.0	14.0	26.0	37.0	VA
33	23	21.9	6.0	17.0	8.0	4.0	1.0	47.0	49.0	43.0	HY
34	23	3.3	5.0	2.0	5.0	1.0	3.0	2.0	4.0	4.0	VA
35	23	9.8	21.0	4.0	6.0	12.0	4.0	2.0	18.0	11.0	HY
36	23	2.8	5.0	4.0	4.0	2.0	1.0	1.0	3.0	2.0	VA
37	23	13.1	18.0	2.0	6.0	2.0	6.0	48.0	6.0	17.0	NVA
38	23	20.6	39.0	5.0	1.0	5.0	33.0	29.0	44.0	9.0	HY
39	23	27.5	33.0	0.0	16.0	47.0	26.0	27.0	19.0	52.0	VA
40	24	3.0	4.0	4.0	5.0	1.0	2.0	1.0	4.0	3.0	VA
41	24	26.0	35.0	32.0	32.0	22.0	15.0	30.0	26.0	16.0	VA
42	24	22.0	35.0	27.0	26.0	0.0	40.0	30.0	16.0	2.0	HY
43	24	15.3	19.0	38.0	15.0	8.0	3.0	18.0	4.0	17.0	HY
44	24	38.0	25.0	47.0	41.0	9.0	51.0	58.0	19.0	54.0	NVA
45	24	3.4	1.0	2.0	3.0	6.0	3.0	3.0	3.0	6.0	NVA
46	24	26.3	27.0	14.0	32.0	12.0	36.0	24.0	30.0	35.0	HY
47	24	18.0	25.0	7.0	14.0	28.0	26.0	15.0	21.0	8.0	HY
48	24	7.5	6.0	12.0	4.0	5.0	5.0	9.0	10.0	9.0	VA
49	24	6.6	11.0	11.0	9.0	2.0	10.0	3.0	5.0	2.0	VA
50	24	17.6	20.0	16.0	23.0	10.0	12.0	16.0	16.0	28.0	HY
51	24	9.9	1.0	18.0	13.0	16.0	9.0	10.0	7.0	5.0	NVA
52	25	2.9	1.0	2.0	6.0	3.0	2.0	5.0	0.0	4.0	VA
53	25	26.9	32.0	39.0	39.0	0.0	36.0	31.0	30.0	8.0	NVA
54	25	25.1	32.0	31.0	17.0	30.0	1.0	33.0	23.0	34.0	HY
55	25	26.5	17.0	35.0	47.0	52.0	22.0	20.0	7.0	12.0	VA
56	25	28.4	44.0	32.0	34.0	20.0	29.0	22.0	17.0	29.0	VA
57	25	19.5	28.0	49.0	17.0	3.0	18.0	14.0	15.0	12.0	VA
58	25	31.4	54.0	18.0	15.0	57.0	43.0	15.0	2.0	47.0	NVA
59	25	10.3	5.0	7.0	7.0	27.0	4.0	23.0	7.0	2.0	HY
60	25	12.0	12.0	3.0	1.0	30.0	13.0	7.0	13.0	17.0	NVA
61	25	3.9	1.0	11.0	1.0	3.0	0.0	4.0	9.0	2.0	HY
62	25	22.8	8.0	7.0	49.0	14.0	27.0	13.0	48.0	16.0	VA
63	25	21.1	20.0	9.0	40.0	15.0	17.0	35.0	16.0	17.0	NVA
64	26	6.1	4.0	3.0	5.0	11.0	4.0	10.0	9.0	3.0	HY
65	26	11.3	6.0	9.0	35.0	14.0	18.0	5.0	2.0	1.0	VA
66	26	17.3	15.0	24.0	17.0	22.0	20.0	3.0	11.0	26.0	NVA
67	26	12.4	4.0	20.0	13.0	14.0	5.0	9.0	19.0	15.0	VA
68	26	16.6	10.0	22.0	15.0	27.0	8.0	15.0	21.0	15.0	NVA
69	26	9.3	0.0	3.0	12.0	15.0	14.0	9.0	9.0	12.0	NVA
70	26	39.9	35.0	49.0	61.0	1.0	60.0	63.0	2.0	48.0	HY
71	26	30.4	25.0	50.0	34.0	25.0	18.0	4.0	40.0	47.0	NVA
72	26	24.5	11.0	9.0	25.0	20.0	32.0	5.0	45.0	49.0	VA
73	26	12.4	13.0	16.0	5.0	16.0	11.0	12.0	17.0	9.0	HY
74	27	36.6	43.0	12.0	32.0	55.0	47.0	46.0	44.0	14.0	HY

Table E.1: Equal–SKU Split Example Reserve Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
75	27	8.1	9.0	1.0	9.0	8.0	10.0	14.0	1.0	13.0	NVA
76	27	21.6	23.0	12.0	29.0	8.0	1.0	4.0	70.0	26.0	NVA
77	27	34.4	48.0	50.0	5.0	38.0	44.0	11.0	33.0	46.0	HY
78	27	23.5	27.0	29.0	4.0	26.0	27.0	12.0	21.0	42.0	HY
79	27	24.4	30.0	17.0	1.0	27.0	8.0	43.0	26.0	43.0	HY
80	27	25.5	26.0	34.0	35.0	51.0	18.0	1.0	38.0	1.0	VA
81	27	7.3	12.0	2.0	15.0	5.0	4.0	6.0	10.0	4.0	NVA
82	27	33.9	33.0	38.0	42.0	40.0	18.0	40.0	39.0	21.0	NVA
83	28	41.5	62.0	47.0	58.0	31.0	52.0	41.0	1.0	40.0	HY
84	28	24.4	38.0	2.0	35.0	23.0	17.0	20.0	36.0	24.0	NVA
85	28	11.6	5.0	1.0	24.0	12.0	1.0	30.0	4.0	16.0	VA
86	28	26.1	7.0	29.0	16.0	52.0	30.0	40.0	12.0	23.0	NVA
87	28	5.9	0.0	5.0	9.0	10.0	4.0	8.0	11.0	0.0	NVA
88	28	14.9	18.0	8.0	32.0	1.0	3.0	8.0	7.0	42.0	VA
89	28	2.6	8.0	4.0	0.0	1.0	1.0	1.0	4.0	2.0	NVA
90	28	22.9	34.0	26.0	10.0	4.0	36.0	42.0	19.0	12.0	NVA
91	28	32.1	33.0	4.0	45.0	48.0	58.0	2.0	35.0	32.0	NVA
92	29	34.8	26.0	40.0	44.0	57.0	25.0	12.0	20.0	54.0	NVA
93	29	31.0	10.0	39.0	38.0	43.0	4.0	21.0	48.0	45.0	VA
94	29	14.9	9.0	12.0	27.0	12.0	2.0	17.0	23.0	17.0	HY
95	29	31.1	39.0	21.0	7.0	8.0	59.0	60.0	27.0	28.0	NVA
96	29	33.3	29.0	47.0	55.0	17.0	52.0	39.0	5.0	22.0	NVA
97	29	33.3	28.0	14.0	6.0	30.0	44.0	51.0	56.0	37.0	NVA
98	29	9.9	16.0	14.0	13.0	6.0	0.0	18.0	12.0	0.0	HY
99	29	15.4	14.0	22.0	1.0	27.0	7.0	14.0	8.0	30.0	NVA
100	29	40.0	71.0	12.0	60.0	24.0	40.0	35.0	55.0	23.0	HY
101	30	21.3	28.0	18.0	30.0	2.0	39.0	39.0	4.0	10.0	VA
102	30	22.4	3.0	17.0	31.0	32.0	15.0	23.0	22.0	36.0	VA
103	30	20.0	36.0	19.0	2.0	22.0	37.0	0.0	28.0	16.0	HY
104	30	22.5	23.0	27.0	3.0	20.0	33.0	19.0	31.0	24.0	NVA
105	30	15.6	17.0	19.0	20.0	6.0	25.0	12.0	11.0	15.0	HY
106	30	6.6	10.0	4.0	8.0	6.0	5.0	5.0	3.0	12.0	VA
107	30	4.3	11.0	3.0	4.0	6.0	3.0	2.0	0.0	5.0	NVA
108	31	20.8	16.0	17.0	20.0	22.0	14.0	15.0	45.0	17.0	NVA
109	31	2.9	5.0	3.0	4.0	3.0	1.0	5.0	0.0	2.0	NVA
110	31	34.5	14.0	59.0	54.0	8.0	46.0	46.0	26.0	23.0	VA
111	31	22.1	16.0	14.0	7.0	42.0	11.0	29.0	19.0	39.0	NVA
112	31	33.1	29.0	18.0	1.0	18.0	62.0	46.0	36.0	55.0	VA
113	31	29.4	29.0	20.0	32.0	47.0	36.0	31.0	31.0	9.0	VA
114	31	6.9	8.0	1.0	2.0	15.0	5.0	4.0	6.0	14.0	NVA
115	32	2.1	2.0	1.0	4.0	3.0	1.0	3.0	1.0	2.0	NVA
116	32	19.4	23.0	15.0	29.0	9.0	28.0	7.0	21.0	23.0	HY
117	32	30.8	23.0	38.0	6.0	46.0	51.0	7.0	73.0	2.0	NVA
118	32	30.0	0.0	29.0	15.0	15.0	65.0	56.0	21.0	39.0	VA
119	32	10.5	15.0	3.0	23.0	1.0	12.0	5.0	8.0	17.0	VA
120	32	31.3	21.0	21.0	40.0	19.0	7.0	41.0	51.0	50.0	HY
121	32	19.4	6.0	10.0	31.0	29.0	30.0	12.0	11.0	26.0	VA
122	33	26.0	62.0	1.0	46.0	6.0	16.0	55.0	9.0	13.0	NVA
123	33	26.3	36.0	36.0	2.0	11.0	20.0	77.0	9.0	19.0	HY
124	33	18.5	12.0	3.0	32.0	10.0	8.0	40.0	23.0	20.0	HY
125	33	27.0	26.0	46.0	41.0	38.0	26.0	23.0	10.0	6.0	NVA
126	33	28.1	49.0	44.0	45.0	21.0	33.0	10.0	20.0	3.0	HY
127	33	4.4	3.0	4.0	10.0	1.0	4.0	1.0	9.0	3.0	NVA
128	34	33.6	19.0	23.0	43.0	42.0	34.0	44.0	1.0	63.0	VA
129	34	14.1	4.0	22.0	7.0	10.0	27.0	15.0	17.0	11.0	VA
130	34	21.6	25.0	39.0	36.0	19.0	4.0	12.0	17.0	21.0	HY
131	34	41.6	6.0	60.0	41.0	80.0	48.0	4.0	71.0	23.0	HY
132	34	19.4	9.0	26.0	23.0	19.0	14.0	28.0	21.0	15.0	HY
133	34	3.9	2.0	3.0	9.0	8.0	3.0	3.0	3.0	0.0	NVA
134	35	8.4	0.0	8.0	9.0	12.0	5.0	12.0	9.0	12.0	HY

Table E.1: Equal–SKU Split Example Reserve Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
135	35	42.0	37.0	82.0	44.0	21.0	12.0	71.0	61.0	8.0	VA
136	35	25.1	12.0	47.0	42.0	46.0	1.0	18.0	35.0	0.0	NVA
137	35	48.5	74.0	48.0	8.0	64.0	59.0	46.0	10.0	79.0	VA
138	35	19.9	5.0	17.0	36.0	26.0	18.0	9.0	35.0	13.0	NVA
139	36	28.4	33.0	13.0	26.0	34.0	20.0	16.0	35.0	50.0	VA
140	36	4.9	2.0	7.0	7.0	1.0	9.0	7.0	0.0	6.0	VA
141	36	2.9	4.0	3.0	5.0	0.0	3.0	3.0	3.0	2.0	VA
142	36	45.6	52.0	39.0	36.0	40.0	34.0	56.0	83.0	25.0	VA
143	36	7.3	5.0	11.0	6.0	11.0	11.0	6.0	4.0	4.0	VA
144	37	44.4	24.0	51.0	89.0	23.0	82.0	28.0	14.0	44.0	HY
145	37	8.1	0.0	6.0	22.0	4.0	0.0	11.0	2.0	20.0	NVA
146	37	17.4	1.0	9.0	3.0	45.0	38.0	31.0	5.0	7.0	HY
147	37	14.4	13.0	21.0	18.0	5.0	7.0	11.0	25.0	15.0	HY
148	37	35.5	59.0	8.0	25.0	64.0	68.0	3.0	12.0	45.0	VA
149	38	38.8	12.0	53.0	42.0	49.0	42.0	62.0	24.0	26.0	VA
150	38	14.3	7.0	27.0	25.0	11.0	11.0	18.0	6.0	9.0	VA
151	38	2.3	1.0	2.0	4.0	1.0	1.0	1.0	4.0	4.0	NVA
152	38	21.6	16.0	10.0	10.0	38.0	36.0	38.0	3.0	22.0	NVA
153	38	15.4	34.0	18.0	10.0	4.0	6.0	7.0	9.0	35.0	NVA
154	39	2.8	6.0	1.0	3.0	1.0	2.0	0.0	4.0	5.0	NVA
155	39	10.9	19.0	1.0	1.0	19.0	12.0	4.0	19.0	12.0	HY
156	39	36.5	36.0	26.0	53.0	63.0	19.0	63.0	7.0	25.0	HY
157	39	33.4	40.0	20.0	44.0	37.0	30.0	35.0	43.0	18.0	HY
158	40	16.3	13.0	17.0	9.0	8.0	28.0	23.0	26.0	6.0	HY
159	40	4.3	3.0	7.0	7.0	1.0	8.0	5.0	3.0	0.0	VA
160	40	32.0	32.0	76.0	23.0	26.0	9.0	49.0	26.0	15.0	NVA
161	40	53.6	26.0	84.0	0.0	76.0	9.0	64.0	84.0	86.0	NVA
162	41	2.8	3.0	2.0	6.0	3.0	2.0	1.0	4.0	1.0	NVA
163	41	29.9	8.0	44.0	41.0	27.0	15.0	33.0	31.0	40.0	NVA
164	41	7.3	8.0	3.0	15.0	15.0	6.0	2.0	8.0	1.0	NVA
165	41	7.9	3.0	15.0	1.0	8.0	6.0	9.0	17.0	4.0	VA
166	42	20.0	16.0	13.0	19.0	17.0	32.0	26.0	7.0	30.0	VA
167	42	14.0	6.0	13.0	7.0	13.0	19.0	12.0	20.0	22.0	HY
168	42	5.0	11.0	1.0	7.0	2.0	10.0	4.0	2.0	3.0	VA
169	42	9.8	4.0	21.0	1.0	14.0	18.0	1.0	10.0	9.0	VA
170	43	8.4	3.0	7.0	14.0	10.0	1.0	3.0	6.0	23.0	NVA
171	43	2.5	4.0	3.0	3.0	2.0	0.0	4.0	2.0	2.0	VA
172	43	13.3	14.0	11.0	22.0	11.0	5.0	18.0	8.0	17.0	VA
173	44	5.5	3.0	9.0	1.0	8.0	3.0	4.0	8.0	8.0	VA
174	44	27.3	31.0	44.0	21.0	19.0	42.0	44.0	5.0	12.0	NVA
175	44	36.5	6.0	13.0	55.0	30.0	1.0	84.0	28.0	75.0	NVA
176	44	55.0	78.0	69.0	10.0	19.0	35.0	77.0	76.0	76.0	HY
177	45	21.4	10.0	5.0	1.0	26.0	27.0	37.0	27.0	38.0	HY
178	45	42.0	51.0	38.0	60.0	48.0	49.0	28.0	10.0	52.0	HY
179	45	26.6	51.0	46.0	1.0	48.0	12.0	8.0	13.0	34.0	HY
180	46	17.8	19.0	32.0	33.0	4.0	10.0	1.0	31.0	12.0	NVA
181	46	3.8	4.0	4.0	5.0	1.0	2.0	3.0	6.0	5.0	NVA
182	46	37.9	14.0	41.0	27.0	37.0	37.0	59.0	45.0	43.0	VA
183	47	2.5	1.0	3.0	2.0	1.0	4.0	2.0	5.0	2.0	HY
184	47	71.0	90.0	62.0	89.0	21.0	32.0	84.0	83.0	107.0	HY
185	47	20.5	4.0	1.0	18.0	21.0	32.0	34.0	30.0	24.0	HY
186	48	64.1	71.0	23.0	63.0	33.0	84.0	75.0	82.0	82.0	NVA
187	48	51.8	58.0	95.0	14.0	86.0	57.0	1.0	52.0	51.0	NVA
188	49	28.0	15.0	42.0	63.0	14.0	28.0	36.0	23.0	3.0	HY
189	49	54.6	67.0	49.0	17.0	104.0	63.0	9.0	106.0	22.0	VA
190	49	61.5	72.0	75.0	64.0	21.0	76.0	73.0	56.0	55.0	VA
191	50	64.4	116.0	27.0	64.0	55.0	32.0	21.0	100.0	100.0	VA
192	50	35.1	74.0	4.0	40.0	5.0	72.0	29.0	48.0	9.0	VA
193	50	22.9	1.0	46.0	37.0	40.0	8.0	16.0	26.0	9.0	NVA
194	51	28.3	50.0	33.0	27.0	21.0	16.0	27.0	34.0	18.0	HY

Table E.1: Equal–SKU Split Example Reserve Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
195	51	2.9	2.0	3.0	0.0	2.0	4.0	5.0	4.0	3.0	VA
196	52	50.6	80.0	48.0	86.0	29.0	20.0	14.0	36.0	92.0	HY
197	52	38.4	15.0	45.0	24.0	37.0	26.0	58.0	57.0	45.0	VA
198	53	78.1	80.0	76.0	94.0	38.0	105.0	32.0	97.0	103.0	VA
199	53	30.6	8.0	18.0	21.0	29.0	6.0	35.0	75.0	53.0	HY
200	53	46.0	11.0	82.0	36.0	79.0	8.0	8.0	70.0	74.0	VA
201	54	34.0	61.0	16.0	50.0	17.0	20.0	54.0	29.0	25.0	VA
202	54	20.6	16.0	38.0	21.0	28.0	35.0	4.0	21.0	2.0	NVA
203	55	38.1	7.0	21.0	70.0	64.0	4.0	19.0	72.0	48.0	NVA
204	55	88.4	109.0	82.0	75.0	58.0	100.0	101.0	114.0	68.0	NVA
205	56	12.4	15.0	3.0	17.0	2.0	31.0	16.0	8.0	7.0	NVA
206	56	80.8	18.0	52.0	118.0	146.0	82.0	66.0	127.0	37.0	HY
207	57	48.1	42.0	34.0	51.0	64.0	73.0	37.0	42.0	42.0	NVA
208	57	76.9	20.0	129.0	95.0	36.0	113.0	85.0	12.0	125.0	HY
209	58	73.1	68.0	81.0	128.0	36.0	9.0	127.0	101.0	35.0	NVA
210	59	33.1	54.0	44.0	24.0	30.0	8.0	43.0	59.0	3.0	HY
211	59	28.1	38.0	16.0	32.0	9.0	33.0	16.0	34.0	47.0	VA
212	60	49.1	66.0	60.0	31.0	61.0	32.0	66.0	12.0	65.0	VA
213	60	28.6	56.0	40.0	8.0	41.0	10.0	10.0	30.0	34.0	VA
214	61	67.4	120.0	118.0	94.0	28.0	93.0	13.0	63.0	10.0	VA
215	61	4.0	3.0	1.0	5.0	2.0	5.0	6.0	4.0	6.0	HY
216	62	64.5	70.0	107.0	13.0	1.0	132.0	93.0	87.0	13.0	NVA
217	63	67.5	80.0	39.0	46.0	61.0	93.0	92.0	48.0	81.0	HY
218	63	72.6	86.0	15.0	55.0	97.0	93.0	84.0	97.0	54.0	VA
219	64	3.3	0.0	4.0	3.0	2.0	2.0	5.0	3.0	7.0	HY
220	65	43.5	63.0	26.0	36.0	31.0	49.0	58.0	47.0	38.0	VA
221	65	30.3	16.0	30.0	34.0	65.0	35.0	40.0	1.0	21.0	HY
222	66	32.0	34.0	50.0	41.0	4.0	45.0	2.0	38.0	42.0	VA
223	67	27.5	6.0	13.0	44.0	46.0	17.0	17.0	39.0	38.0	HY
224	68	14.6	15.0	11.0	22.0	4.0	16.0	25.0	11.0	13.0	NVA
225	68	21.5	36.0	29.0	25.0	15.0	4.0	8.0	24.0	31.0	VA
226	69	91.9	169.0	51.0	90.0	112.0	87.0	38.0	56.0	132.0	HY
227	70	48.0	27.0	59.0	52.0	28.0	53.0	73.0	32.0	60.0	HY
228	71	27.8	25.0	18.0	33.0	6.0	13.0	53.0	31.0	43.0	NVA
229	72	58.6	99.0	14.0	32.0	31.0	53.0	112.0	100.0	28.0	HY
230	73	74.6	65.0	147.0	66.0	119.0	78.0	17.0	78.0	27.0	NVA
231	73	44.9	72.0	17.0	68.0	17.0	27.0	47.0	81.0	30.0	VA
232	74	100.0	73.0	99.0	192.0	32.0	98.0	176.0	70.0	60.0	HY
233	75	25.6	27.0	37.0	18.0	22.0	41.0	29.0	23.0	8.0	NVA
234	76	69.6	132.0	28.0	89.0	91.0	84.0	81.0	28.0	24.0	NVA
235	77	71.9	6.0	19.0	83.0	59.0	124.0	118.0	86.0	80.0	VA
236	78	51.9	82.0	70.0	77.0	75.0	41.0	37.0	27.0	6.0	HY
237	79	32.9	34.0	35.0	48.0	35.0	27.0	31.0	28.0	25.0	VA
238	80	6.0	6.0	2.0	6.0	5.0	11.0	2.0	7.0	9.0	NVA
239	82	98.0	64.0	90.0	83.0	160.0	115.0	42.0	141.0	89.0	VA
240	83	39.3	62.0	54.0	44.0	12.0	48.0	81.0	3.0	10.0	VA
241	84	51.1	85.0	57.0	39.0	103.0	68.0	4.0	50.0	3.0	NVA
242	85	27.6	41.0	25.0	46.0	9.0	28.0	37.0	23.0	12.0	VA
243	86	30.6	35.0	1.0	59.0	24.0	11.0	30.0	44.0	41.0	HY
244	88	153.1	198.0	117.0	212.0	171.0	216.0	76.0	169.0	66.0	HY
245	89	104.8	77.0	140.0	119.0	113.0	99.0	71.0	87.0	132.0	VA
246	91	2.4	0.0	0.0	2.0	3.0	4.0	2.0	5.0	3.0	VA
247	92	56.9	46.0	72.0	17.0	81.0	66.0	73.0	82.0	18.0	HY
248	94	51.0	85.0	97.0	53.0	7.0	58.0	10.0	69.0	29.0	HY
249	95	32.1	34.0	3.0	43.0	21.0	32.0	14.0	64.0	46.0	NVA
250	97	126.5	150.0	25.0	201.0	171.0	130.0	31.0	151.0	153.0	NVA
251	98	85.4	1.0	132.0	67.0	110.0	31.0	129.0	77.0	136.0	VA
252	100	63.6	139.0	46.0	13.0	28.0	117.0	51.0	4.0	111.0	NVA
253	102	133.0	129.0	44.0	212.0	97.0	170.0	79.0	119.0	214.0	NVA
254	104	55.3	28.0	6.0	82.0	22.0	78.0	67.0	81.0	78.0	VA

Table E.1: Equal–SKU Split Example Reserve Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
255	106	11.0	19.0	2.0	3.0	12.0	7.0	15.0	18.0	12.0	HY
256	108	130.6	116.0	177.0	140.0	156.0	181.0	95.0	66.0	114.0	NVA
257	110	119.4	221.0	36.0	39.0	141.0	212.0	96.0	101.0	109.0	VA
258	112	136.5	168.0	96.0	13.0	216.0	256.0	168.0	118.0	57.0	NVA
259	114	54.9	52.0	71.0	9.0	57.0	48.0	69.0	57.0	76.0	VA
260	117	37.8	10.0	51.0	38.0	53.0	36.0	46.0	14.0	54.0	VA
261	119	83.1	74.0	103.0	74.0	131.0	67.0	31.0	30.0	155.0	HY
262	122	48.9	79.0	41.0	23.0	70.0	49.0	47.0	54.0	28.0	NVA
263	125	121.3	231.0	124.0	28.0	86.0	154.0	202.0	47.0	98.0	NVA
264	128	58.3	48.0	22.0	44.0	104.0	99.0	41.0	13.0	95.0	HY
265	131	42.5	36.0	43.0	47.0	48.0	59.0	50.0	41.0	16.0	HY
266	134	48.0	28.0	17.0	23.0	71.0	74.0	51.0	29.0	91.0	HY
267	138	131.8	270.0	109.0	70.0	25.0	72.0	5.0	189.0	314.0	HY
268	141	188.4	310.0	337.0	89.0	179.0	50.0	241.0	103.0	198.0	HY
269	145	198.0	202.0	342.0	104.0	39.0	271.0	179.0	162.0	285.0	HY
270	149	4.4	6.0	3.0	4.0	7.0	1.0	3.0	6.0	5.0	HY
271	154	174.4	223.0	315.0	235.0	133.0	55.0	256.0	66.0	112.0	HY
272	158	195.1	0.0	121.0	176.0	269.0	326.0	272.0	53.0	344.0	VA
273	163	49.9	36.0	42.0	70.0	20.0	68.0	74.0	69.0	20.0	HY
274	168	57.3	5.0	52.0	81.0	45.0	68.0	50.0	65.0	92.0	NVA
275	174	128.1	140.0	79.0	85.0	131.0	140.0	168.0	100.0	182.0	HY
276	180	212.6	406.0	37.0	86.0	228.0	27.0	376.0	319.0	222.0	HY
277	187	221.1	210.0	256.0	46.0	196.0	225.0	269.0	312.0	255.0	VA
278	194	71.0	123.0	180.0	59.0	26.0	51.0	0.0	68.0	61.0	HY
279	202	17.1	8.0	30.0	13.0	10.0	4.0	26.0	15.0	31.0	HY
280	210	144.6	203.0	197.0	26.0	43.0	140.0	199.0	122.0	227.0	NVA
281	219	48.6	27.0	47.0	49.0	103.0	44.0	13.0	81.0	25.0	HY
282	230	255.4	135.0	404.0	368.0	256.0	132.0	32.0	186.0	530.0	VA
283	241	28.1	24.0	67.0	6.0	40.0	13.0	4.0	34.0	37.0	HY
284	253	278.8	374.0	164.0	48.0	313.0	474.0	283.0	99.0	475.0	VA
285	267	139.9	111.0	187.0	76.0	162.0	98.0	191.0	103.0	191.0	VA
286	283	358.8	520.0	287.0	486.0	384.0	416.0	32.0	173.0	572.0	VA
287	301	121.0	150.0	192.0	47.0	180.0	75.0	197.0	0.0	127.0	HY
288	322	117.9	164.0	136.0	33.0	126.0	51.0	177.0	87.0	169.0	HY
289	346	385.1	764.0	346.0	435.0	33.0	506.0	789.0	124.0	84.0	HY
290	374	76.6	78.0	64.0	62.0	77.0	103.0	51.0	65.0	113.0	NVA
291	408	189.9	180.0	328.0	267.0	171.0	189.0	176.0	23.0	185.0	HY
292	449	276.4	90.0	157.0	463.0	81.0	439.0	277.0	677.0	27.0	HY
293	500	66.8	128.0	52.0	70.0	2.0	131.0	10.0	87.0	54.0	HY
294	566	349.8	533.0	1.0	30.0	400.0	461.0	791.0	462.0	120.0	HY
295	654	716.8	274.0	671.0	1232.0	724.0	910.0	169.0	1099.0	655.0	VA
296	778	410.3	117.0	143.0	264.0	139.0	486.0	738.0	839.0	556.0	NVA
297	968	218.0	397.0	450.0	3.0	88.0	1.0	317.0	324.0	164.0	VA
298	1300	717.1	1023.0	25.0	1328.0	1079.0	573.0	135.0	1235.0	339.0	NVA
299	2060	2122.3	2209.0	2104.0	1059.0	1158.0	2024.0	2955.0	2511.0	2958.0	VA
300	20365	14071.8	18155.0	15498.0	1092.0	24565.0	8921.0	20914.0	21938.0	1491.0	VA

Appendix F

Equal–SKU Split Example Reserve Data – Separate

In this appendix we present the separate data for the reserve department of the equal–SKU split example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Avg. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table F.1: Equal–SKU Split Example Reserve Data – Separate NVA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
3	21	19.5	23.0	28.0	3.0	30.0	0.0	21.0	29.0	22.0	HY - NVA
17	22	13.0	3.0	19.0	23.0	1.0	19.0	2.0	19.0	18.0	HY - NVA
22	22	21.3	7.0	8.0	31.0	23.0	29.0	20.0	25.0	27.0	HY - NVA
24	22	18.9	32.0	12.0	36.0	2.0	23.0	32.0	12.0	2.0	HY - NVA
27	23	22.6	36.0	11.0	26.0	31.0	10.0	32.0	21.0	14.0	HY - NVA
29	23	9.1	10.0	12.0	5.0	12.0	12.0	11.0	9.0	2.0	HY - NVA
30	23	2.5	3.0	1.0	3.0	3.0	4.0	4.0	2.0	0.0	HY - NVA
33	23	15.8	5.0	12.0	6.0	3.0	1.0	33.0	35.0	31.0	HY - NVA
35	23	7.3	15.0	3.0	5.0	9.0	3.0	2.0	13.0	8.0	HY - NVA
38	23	15.0	28.0	4.0	1.0	4.0	24.0	21.0	31.0	7.0	HY - NVA
42	24	15.8	25.0	19.0	19.0	0.0	28.0	21.0	12.0	2.0	HY - NVA
43	24	11.1	14.0	27.0	11.0	6.0	3.0	13.0	3.0	12.0	HY - NVA
46	24	18.8	19.0	10.0	23.0	9.0	26.0	17.0	21.0	25.0	HY - NVA
47	24	13.0	18.0	5.0	10.0	20.0	19.0	11.0	15.0	6.0	HY - NVA

Table F.1: Equal–SKU Split Example Reserve Data – Separate NVA *(continued).*

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
50	24	12.9	14.0	12.0	17.0	7.0	9.0	12.0	12.0	20.0	HY - NVA
54	25	18.0	23.0	22.0	12.0	21.0	1.0	24.0	17.0	24.0	HY - NVA
59	25	7.5	4.0	5.0	5.0	19.0	3.0	17.0	5.0	2.0	HY - NVA
61	25	3.1	1.0	8.0	1.0	3.0	0.0	3.0	7.0	2.0	HY - NVA
64	26	4.8	3.0	3.0	4.0	8.0	3.0	7.0	7.0	3.0	HY - NVA
70	26	28.4	25.0	35.0	43.0	1.0	42.0	45.0	2.0	34.0	HY - NVA
73	26	9.3	10.0	12.0	4.0	12.0	8.0	9.0	12.0	7.0	HY - NVA
74	27	26.1	31.0	9.0	23.0	39.0	33.0	33.0	31.0	10.0	HY - NVA
77	27	24.5	34.0	35.0	4.0	27.0	31.0	8.0	24.0	33.0	HY - NVA
78	27	16.9	19.0	21.0	3.0	19.0	19.0	9.0	15.0	30.0	HY - NVA
79	27	17.5	21.0	12.0	1.0	19.0	6.0	31.0	19.0	31.0	HY - NVA
83	28	29.4	44.0	33.0	41.0	22.0	37.0	29.0	1.0	28.0	HY - NVA
94	29	10.9	7.0	9.0	19.0	9.0	2.0	12.0	17.0	12.0	HY - NVA
98	29	7.4	12.0	10.0	10.0	5.0	0.0	13.0	9.0	0.0	HY - NVA
100	29	28.4	50.0	9.0	42.0	17.0	28.0	25.0	39.0	17.0	HY - NVA
103	30	14.5	26.0	14.0	2.0	16.0	26.0	0.0	20.0	12.0	HY - NVA
105	30	11.4	12.0	14.0	14.0	5.0	18.0	9.0	8.0	11.0	HY - NVA
116	32	14.1	17.0	11.0	21.0	7.0	20.0	5.0	15.0	17.0	HY - NVA
120	32	22.1	15.0	15.0	28.0	14.0	5.0	29.0	36.0	35.0	HY - NVA
123	33	18.9	26.0	26.0	2.0	8.0	14.0	54.0	7.0	14.0	HY - NVA
124	33	13.4	9.0	3.0	23.0	7.0	6.0	28.0	17.0	14.0	HY - NVA
126	33	20.1	35.0	31.0	32.0	15.0	24.0	7.0	14.0	3.0	HY - NVA
130	34	15.6	18.0	28.0	26.0	14.0	3.0	9.0	12.0	15.0	HY - NVA
131	34	29.5	5.0	42.0	29.0	56.0	34.0	3.0	50.0	17.0	HY - NVA
132	34	14.1	7.0	19.0	17.0	14.0	10.0	20.0	15.0	11.0	HY - NVA
134	35	6.4	0.0	6.0	7.0	9.0	4.0	9.0	7.0	9.0	HY - NVA
144	37	31.5	17.0	36.0	63.0	17.0	58.0	20.0	10.0	31.0	HY - NVA
146	37	12.6	1.0	7.0	3.0	32.0	27.0	22.0	4.0	5.0	HY - NVA
147	37	10.5	10.0	15.0	13.0	4.0	5.0	8.0	18.0	11.0	HY - NVA
155	39	8.1	14.0	1.0	1.0	14.0	9.0	3.0	14.0	9.0	HY - NVA
156	39	26.3	26.0	19.0	38.0	45.0	14.0	45.0	5.0	18.0	HY - NVA
157	39	23.6	28.0	14.0	31.0	26.0	21.0	25.0	31.0	13.0	HY - NVA
158	40	12.0	10.0	12.0	7.0	6.0	20.0	17.0	19.0	5.0	HY - NVA
167	42	10.4	5.0	10.0	5.0	10.0	14.0	9.0	14.0	16.0	HY - NVA
176	44	39.0	55.0	49.0	7.0	14.0	25.0	54.0	54.0	54.0	HY - NVA
177	45	15.3	7.0	4.0	1.0	19.0	19.0	26.0	19.0	27.0	HY - NVA
178	45	29.8	36.0	27.0	42.0	34.0	35.0	20.0	7.0	37.0	HY - NVA
179	45	19.1	36.0	33.0	1.0	34.0	9.0	6.0	10.0	24.0	HY - NVA
183	47	2.3	1.0	3.0	2.0	1.0	3.0	2.0	4.0	2.0	HY - NVA
184	47	50.1	63.0	44.0	63.0	15.0	23.0	59.0	59.0	75.0	HY - NVA
185	47	14.6	3.0	1.0	13.0	15.0	23.0	24.0	21.0	17.0	HY - NVA
188	49	20.3	11.0	30.0	45.0	10.0	20.0	26.0	17.0	3.0	HY - NVA
194	51	20.1	35.0	24.0	19.0	15.0	12.0	19.0	24.0	13.0	HY - NVA
196	52	35.9	56.0	34.0	61.0	21.0	14.0	10.0	26.0	65.0	HY - NVA
199	53	22.0	6.0	13.0	15.0	21.0	5.0	25.0	53.0	38.0	HY - NVA
206	56	57.0	13.0	37.0	83.0	103.0	58.0	47.0	89.0	26.0	HY - NVA
208	57	54.4	14.0	91.0	67.0	26.0	80.0	60.0	9.0	88.0	HY - NVA
210	59	23.6	38.0	31.0	17.0	21.0	6.0	31.0	42.0	3.0	HY - NVA
215	61	3.4	3.0	1.0	4.0	2.0	4.0	5.0	3.0	5.0	HY - NVA
217	63	47.8	56.0	28.0	33.0	43.0	66.0	65.0	34.0	57.0	HY - NVA
219	64	2.8	0.0	3.0	3.0	2.0	2.0	4.0	3.0	5.0	HY - NVA
221	65	21.5	12.0	21.0	24.0	46.0	25.0	28.0	1.0	15.0	HY - NVA
223	67	19.8	5.0	10.0	31.0	33.0	12.0	12.0	28.0	27.0	HY - NVA
226	69	64.8	119.0	36.0	63.0	79.0	61.0	27.0	40.0	93.0	HY - NVA
227	70	34.1	19.0	42.0	37.0	20.0	38.0	52.0	23.0	42.0	HY - NVA
229	72	41.5	70.0	10.0	23.0	22.0	38.0	79.0	70.0	20.0	HY - NVA
232	74	70.5	52.0	70.0	135.0	23.0	69.0	124.0	49.0	42.0	HY - NVA
236	78	36.6	58.0	49.0	54.0	53.0	29.0	26.0	19.0	5.0	HY - NVA
243	86	21.8	25.0	1.0	42.0	17.0	8.0	21.0	31.0	29.0	HY - NVA

Table F.1: Equal–SKU Split Example Reserve Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
244	88	107.8	139.0	82.0	149.0	120.0	152.0	54.0	119.0	47.0	HY - NVA
247	92	40.4	33.0	51.0	12.0	57.0	47.0	52.0	58.0	13.0	HY - NVA
248	94	36.1	60.0	68.0	38.0	5.0	41.0	7.0	49.0	21.0	HY - NVA
255	106	8.3	14.0	2.0	3.0	9.0	5.0	11.0	13.0	9.0	HY - NVA
261	119	58.5	52.0	73.0	52.0	92.0	47.0	22.0	21.0	109.0	HY - NVA
264	128	41.3	34.0	16.0	31.0	73.0	70.0	29.0	10.0	67.0	HY - NVA
265	131	30.3	26.0	31.0	33.0	34.0	42.0	35.0	29.0	12.0	HY - NVA
266	134	34.0	20.0	12.0	17.0	50.0	52.0	36.0	21.0	64.0	HY - NVA
267	138	92.6	189.0	77.0	49.0	18.0	51.0	4.0	133.0	220.0	HY - NVA
268	141	132.3	217.0	236.0	63.0	126.0	35.0	169.0	73.0	139.0	HY - NVA
269	145	139.1	142.0	240.0	73.0	28.0	190.0	126.0	114.0	200.0	HY - NVA
270	149	3.6	5.0	3.0	3.0	5.0	1.0	3.0	5.0	4.0	HY - NVA
271	154	122.8	157.0	221.0	165.0	94.0	39.0	180.0	47.0	79.0	HY - NVA
273	163	35.3	26.0	30.0	49.0	14.0	48.0	52.0	49.0	14.0	HY - NVA
275	174	90.0	98.0	56.0	60.0	92.0	98.0	118.0	70.0	128.0	HY - NVA
276	180	149.4	285.0	26.0	61.0	160.0	19.0	264.0	224.0	156.0	HY - NVA
278	194	50.1	87.0	126.0	42.0	19.0	36.0	0.0	48.0	43.0	HY - NVA
279	202	12.4	6.0	21.0	10.0	7.0	3.0	19.0	11.0	22.0	HY - NVA
281	219	34.5	19.0	33.0	35.0	73.0	31.0	10.0	57.0	18.0	HY - NVA
283	241	20.0	17.0	47.0	5.0	28.0	10.0	3.0	24.0	26.0	HY - NVA
287	301	84.9	105.0	135.0	33.0	126.0	53.0	138.0	0.0	89.0	HY - NVA
288	322	83.0	115.0	96.0	24.0	89.0	36.0	124.0	61.0	119.0	HY - NVA
289	346	270.1	535.0	243.0	305.0	24.0	355.0	553.0	87.0	59.0	HY - NVA
291	408	133.4	126.0	230.0	187.0	120.0	133.0	124.0	17.0	130.0	HY - NVA
292	449	193.8	63.0	110.0	325.0	57.0	308.0	194.0	474.0	19.0	HY - NVA
293	500	47.0	90.0	37.0	49.0	2.0	92.0	7.0	61.0	38.0	HY - NVA
294	566	245.1	374.0	1.0	21.0	280.0	323.0	554.0	324.0	84.0	HY - NVA

Table F.2: Equal–SKU Split Example Reserve Data – Separate VA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
3	21	18.0	21.0	26.0	2.0	28.0	0.0	19.0	27.0	21.0	HY - VA
17	22	11.9	3.0	17.0	21.0	1.0	17.0	2.0	17.0	17.0	HY - VA
22	22	19.8	6.0	8.0	29.0	21.0	27.0	19.0	23.0	25.0	HY - VA
24	22	17.8	30.0	12.0	34.0	2.0	21.0	30.0	11.0	2.0	HY - VA
27	23	21.4	34.0	10.0	25.0	29.0	10.0	30.0	20.0	13.0	HY - VA
29	23	8.8	10.0	12.0	4.0	12.0	12.0	10.0	8.0	2.0	HY - VA
30	23	2.1	2.0	1.0	2.0	2.0	4.0	4.0	2.0	0.0	HY - VA
33	23	14.6	4.0	12.0	6.0	3.0	1.0	31.0	32.0	28.0	HY - VA
35	23	6.8	14.0	3.0	4.0	8.0	3.0	2.0	12.0	8.0	HY - VA
38	23	13.9	26.0	4.0	1.0	4.0	22.0	19.0	29.0	6.0	HY - VA
42	24	14.6	23.0	18.0	17.0	0.0	26.0	20.0	11.0	2.0	HY - VA
43	24	10.4	13.0	25.0	10.0	6.0	2.0	12.0	3.0	12.0	HY - VA
46	24	17.5	18.0	10.0	21.0	8.0	24.0	16.0	20.0	23.0	HY - VA
47	24	12.3	17.0	5.0	10.0	19.0	17.0	10.0	14.0	6.0	HY - VA
50	24	11.9	13.0	11.0	15.0	7.0	8.0	11.0	11.0	19.0	HY - VA
54	25	16.9	21.0	21.0	12.0	20.0	1.0	22.0	15.0	23.0	HY - VA
59	25	7.1	4.0	5.0	5.0	18.0	3.0	15.0	5.0	2.0	HY - VA
61	25	2.9	1.0	8.0	1.0	2.0	0.0	3.0	6.0	2.0	HY - VA
64	26	4.4	3.0	2.0	4.0	8.0	3.0	7.0	6.0	2.0	HY - VA
70	26	26.3	23.0	32.0	40.0	1.0	39.0	41.0	2.0	32.0	HY - VA
73	26	8.6	9.0	11.0	4.0	11.0	8.0	8.0	12.0	6.0	HY - VA
74	27	24.1	28.0	8.0	21.0	36.0	31.0	30.0	29.0	10.0	HY - VA
77	27	22.9	32.0	33.0	4.0	25.0	29.0	8.0	22.0	30.0	HY - VA
78	27	15.6	18.0	19.0	3.0	17.0	18.0	8.0	14.0	28.0	HY - VA
79	27	16.3	20.0	12.0	1.0	18.0	6.0	28.0	17.0	28.0	HY - VA
83	28	27.4	41.0	31.0	38.0	21.0	34.0	27.0	1.0	26.0	HY - VA

Table F.2: Equal–SKU Split Example Reserve Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
94	29	10.1	6.0	8.0	18.0	8.0	2.0	12.0	15.0	12.0	HY - VA
98	29	6.8	11.0	10.0	9.0	4.0	0.0	12.0	8.0	0.0	HY - VA
100	29	26.3	47.0	8.0	39.0	16.0	26.0	23.0	36.0	15.0	HY - VA
103	30	13.6	24.0	13.0	2.0	15.0	25.0	0.0	19.0	11.0	HY - VA
105	30	10.6	12.0	13.0	13.0	4.0	17.0	8.0	8.0	10.0	HY - VA
116	32	12.9	15.0	10.0	19.0	6.0	19.0	5.0	14.0	15.0	HY - VA
120	32	20.8	14.0	14.0	26.0	13.0	5.0	27.0	34.0	33.0	HY - VA
123	33	17.6	24.0	24.0	2.0	8.0	13.0	51.0	6.0	13.0	HY - VA
124	33	12.3	8.0	2.0	21.0	7.0	6.0	26.0	15.0	13.0	HY - VA
126	33	18.6	32.0	29.0	30.0	14.0	22.0	7.0	13.0	2.0	HY - VA
130	34	14.6	17.0	26.0	24.0	13.0	3.0	8.0	12.0	14.0	HY - VA
131	34	27.4	4.0	39.0	27.0	52.0	32.0	3.0	47.0	15.0	HY - VA
132	34	13.0	6.0	17.0	15.0	13.0	10.0	19.0	14.0	10.0	HY - VA
134	35	5.8	0.0	6.0	6.0	8.0	4.0	8.0	6.0	8.0	HY - VA
144	37	29.4	16.0	34.0	58.0	15.0	54.0	19.0	10.0	29.0	HY - VA
146	37	11.8	1.0	6.0	2.0	30.0	25.0	21.0	4.0	5.0	HY - VA
147	37	9.9	9.0	14.0	12.0	4.0	5.0	8.0	17.0	10.0	HY - VA
155	39	7.5	13.0	1.0	1.0	13.0	8.0	3.0	13.0	8.0	HY - VA
156	39	24.1	24.0	17.0	35.0	41.0	13.0	41.0	5.0	17.0	HY - VA
157	39	22.0	26.0	13.0	29.0	25.0	20.0	23.0	28.0	12.0	HY - VA
158	40	11.0	9.0	12.0	6.0	6.0	19.0	15.0	17.0	4.0	HY - VA
167	42	9.5	4.0	9.0	5.0	9.0	13.0	8.0	13.0	15.0	HY - VA
176	44	36.3	51.0	45.0	7.0	13.0	23.0	51.0	50.0	50.0	HY - VA
177	45	14.4	7.0	4.0	1.0	17.0	18.0	25.0	18.0	25.0	HY - VA
178	45	27.8	34.0	25.0	39.0	32.0	32.0	19.0	7.0	34.0	HY - VA
179	45	17.9	34.0	30.0	1.0	32.0	8.0	6.0	9.0	23.0	HY - VA
183	47	2.1	1.0	2.0	2.0	1.0	3.0	2.0	4.0	2.0	HY - VA
184	47	46.5	59.0	41.0	58.0	14.0	21.0	55.0	54.0	70.0	HY - VA
185	47	13.8	3.0	1.0	12.0	14.0	21.0	23.0	20.0	16.0	HY - VA
188	49	18.6	10.0	28.0	41.0	10.0	19.0	24.0	15.0	2.0	HY - VA
194	51	18.9	33.0	22.0	18.0	14.0	11.0	18.0	23.0	12.0	HY - VA
196	52	33.3	52.0	32.0	56.0	19.0	13.0	10.0	24.0	60.0	HY - VA
199	53	20.3	6.0	12.0	14.0	19.0	4.0	23.0	49.0	35.0	HY - VA
206	56	52.9	12.0	34.0	77.0	95.0	54.0	43.0	83.0	25.0	HY - VA
208	57	50.4	13.0	84.0	62.0	24.0	74.0	56.0	8.0	82.0	HY - VA
210	59	22.0	36.0	29.0	16.0	20.0	6.0	28.0	39.0	2.0	HY - VA
215	61	3.0	2.0	1.0	4.0	2.0	4.0	4.0	3.0	4.0	HY - VA
217	63	44.3	52.0	26.0	30.0	40.0	61.0	60.0	32.0	53.0	HY - VA
219	64	2.5	0.0	3.0	2.0	2.0	2.0	4.0	2.0	5.0	HY - VA
221	65	20.1	11.0	20.0	23.0	43.0	23.0	26.0	1.0	14.0	HY - VA
223	67	18.4	4.0	9.0	29.0	30.0	12.0	12.0	26.0	25.0	HY - VA
226	69	60.1	110.0	34.0	59.0	73.0	57.0	25.0	37.0	86.0	HY - VA
227	70	31.6	18.0	39.0	34.0	19.0	35.0	48.0	21.0	39.0	HY - VA
229	72	38.6	65.0	10.0	21.0	21.0	35.0	73.0	65.0	19.0	HY - VA
232	74	65.4	48.0	65.0	125.0	21.0	64.0	115.0	46.0	39.0	HY - VA
236	78	34.3	54.0	46.0	51.0	49.0	27.0	25.0	18.0	4.0	HY - VA
243	86	20.4	23.0	1.0	39.0	16.0	8.0	20.0	29.0	27.0	HY - VA
244	88	100.0	129.0	77.0	138.0	112.0	141.0	50.0	110.0	43.0	HY - VA
247	92	37.4	30.0	47.0	12.0	53.0	43.0	48.0	54.0	12.0	HY - VA
248	94	33.6	56.0	64.0	35.0	5.0	38.0	7.0	45.0	19.0	HY - VA
255	106	7.5	13.0	2.0	2.0	8.0	5.0	10.0	12.0	8.0	HY - VA
261	119	54.6	49.0	67.0	49.0	86.0	44.0	21.0	20.0	101.0	HY - VA
264	128	38.4	32.0	15.0	29.0	68.0	65.0	27.0	9.0	62.0	HY - VA
265	131	28.1	24.0	28.0	31.0	32.0	39.0	33.0	27.0	11.0	HY - VA
266	134	31.9	19.0	12.0	15.0	47.0	49.0	34.0	19.0	60.0	HY - VA
267	138	86.1	176.0	71.0	46.0	17.0	47.0	4.0	123.0	205.0	HY - VA
268	141	122.9	202.0	220.0	58.0	117.0	33.0	157.0	67.0	129.0	HY - VA
269	145	129.4	132.0	223.0	68.0	26.0	177.0	117.0	106.0	186.0	HY - VA
270	149	3.1	4.0	2.0	3.0	5.0	1.0	2.0	4.0	4.0	HY - VA
271	154	113.6	145.0	205.0	153.0	87.0	36.0	167.0	43.0	73.0	HY - VA

Table F.2: Equal–SKU Split Example Reserve Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
273	163	32.9	24.0	28.0	46.0	13.0	45.0	49.0	45.0	13.0	HY - VA
275	174	83.8	91.0	52.0	56.0	86.0	91.0	110.0	65.0	119.0	HY - VA
276	180	138.8	264.0	25.0	56.0	149.0	18.0	245.0	208.0	145.0	HY - VA
278	194	46.5	80.0	117.0	39.0	17.0	34.0	0.0	45.0	40.0	HY - VA
279	202	11.6	6.0	20.0	9.0	7.0	3.0	17.0	10.0	21.0	HY - VA
281	219	32.0	18.0	31.0	32.0	67.0	29.0	9.0	53.0	17.0	HY - VA
283	241	18.8	16.0	44.0	4.0	26.0	9.0	3.0	23.0	25.0	HY - VA
287	301	79.0	98.0	125.0	31.0	117.0	49.0	129.0	0.0	83.0	HY - VA
288	322	77.1	107.0	89.0	22.0	82.0	34.0	116.0	57.0	110.0	HY - VA
289	346	250.6	497.0	225.0	283.0	22.0	329.0	513.0	81.0	55.0	HY - VA
291	408	123.9	117.0	214.0	174.0	112.0	123.0	115.0	15.0	121.0	HY - VA
292	449	180.3	59.0	103.0	301.0	53.0	286.0	181.0	441.0	18.0	HY - VA
293	500	44.0	84.0	34.0	46.0	2.0	86.0	7.0	57.0	36.0	HY - VA
294	566	227.8	347.0	1.0	20.0	260.0	300.0	515.0	301.0	78.0	HY - VA

Appendix G

Equal–SKU Split Example Reserve Tradeoff Results

In this appendix we present the tradeoff results for the reserve department of the equal–SKU split example. The first column represents the layout. A number in the first column represents the SKU which has been moved to the non-hybrid area. The column labeled "Total Dist/Tour" represents the distance per tour for the given layout. The column labeled "Retrievals/Hour per Operator" represents the number of retrievals per hour per operator for the given layout. The column labeled "Area" represents the area required for the given layout. The column labeled "Labor Cost" represents the total cost of labor for the given layout. The column labeled "WH Cost" represents the total cost of warehouse space for the given layout. The column labeled "Total Cost" represents the total cost of the given layout. The column labeled "Change" represents the change in cost from the previous layout.

Table G.1: Equal–SKU Split Example Reserve Tradeoff Results.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
Combined	1544.71	9.32	32760	$156,438	$163,800	$320,238	
Separate	1197.69	12.02	35840	$121,294	$179,200	$300,494	
Initial HY	1424.32	10.11	36960	$144,245	$184,800	$329,045	
270	1424.05	10.11	36960	$144,218	$184,800	$329,018	$28
219	1423.93	10.11	36960	$144,206	$184,800	$329,006	$12
183	1423.84	10.11	36960	$144,197	$184,800	$328,997	$9

Table G.1: Equal–SKU Split Example Reserve Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
215	1423.73	10.11	36960	$144,186	$184,800	$328,986	$11
279	1423.36	10.12	36960	$144,149	$184,800	$328,949	$37
255	1423.17	10.12	36960	$144,129	$184,800	$328,929	$20
283	1422.73	10.12	40656	$144,085	$203,280	$347,365	-$18,436
30	1422.69	10.12	40656	$144,080	$203,280	$347,360	$4
293	1421.78	10.13	40656	$143,988	$203,280	$347,268	$92
61	1421.73	10.13	40656	$143,984	$203,280	$347,264	$5
281	1421.33	10.13	40656	$143,943	$203,280	$347,223	$40
64	1421.29	10.13	40656	$143,938	$203,280	$347,218	$5
134	1421.22	10.13	40656	$143,932	$203,280	$347,212	$6
155	1421.15	10.13	40656	$143,925	$203,280	$347,205	$7
273	1420.86	10.13	40656	$143,895	$203,280	$347,175	$30
265	1420.62	10.14	40656	$143,870	$203,280	$347,150	$24
167	1420.54	10.14	40656	$143,863	$203,280	$347,143	$8
98	1420.49	10.14	40656	$143,857	$203,280	$347,137	$5
243	1420.33	10.14	40656	$143,841	$203,280	$347,121	$16
266	1420.09	10.14	40656	$143,817	$203,280	$347,097	$25
278	1419.73	10.14	40656	$143,781	$203,280	$347,061	$36
288	1419.15	10.15	40656	$143,721	$203,280	$347,001	$59
147	1419.08	10.15	40656	$143,715	$203,280	$346,995	$7
287	1418.53	10.15	40656	$143,659	$203,280	$346,939	$56
59	1418.48	10.15	40656	$143,654	$203,280	$346,934	$5
158	1418.41	10.15	40656	$143,647	$203,280	$346,927	$7
223	1418.29	10.15	40656	$143,635	$203,280	$346,915	$12
35	1418.25	10.15	40656	$143,630	$203,280	$346,910	$4
185	1418.16	10.15	40656	$143,622	$203,280	$346,902	$9
264	1417.93	10.16	40656	$143,598	$203,280	$346,878	$24
221	1417.81	10.16	40656	$143,586	$203,280	$346,866	$12
291	1417.07	10.16	40656	$143,511	$203,280	$346,791	$75
73	1417.02	10.16	40656	$143,506	$203,280	$346,786	$5
146	1416.95	10.16	40656	$143,499	$203,280	$346,779	$7
177	1416.87	10.16	40656	$143,491	$203,280	$346,771	$8
94	1416.82	10.16	40656	$143,485	$203,280	$346,765	$5
105	1416.76	10.16	40656	$143,480	$203,280	$346,760	$6
248	1416.59	10.17	44352	$143,463	$221,760	$365,223	-$18,463
29	1416.55	10.17	44352	$143,458	$221,760	$365,218	$4
194	1416.46	10.17	44352	$143,449	$221,760	$365,209	$9
124	1416.40	10.17	44352	$143,443	$221,760	$365,203	$6
132	1416.33	10.17	44352	$143,437	$221,760	$365,197	$6
210	1416.23	10.17	44352	$143,426	$221,760	$365,186	$11
188	1416.14	10.17	44352	$143,417	$221,760	$365,177	$9
199	1416.04	10.17	44352	$143,407	$221,760	$365,167	$10
179	1415.96	10.17	44352	$143,399	$221,760	$365,159	$8
116	1415.90	10.17	44352	$143,393	$221,760	$365,153	$6
292	1415.08	10.18	48048	$143,310	$240,240	$383,550	-$18,397
294	1414.05	10.18	44352	$143,206	$221,760	$364,966	$18,584
247	1413.89	10.18	44352	$143,189	$221,760	$364,949	$17
130	1413.82	10.19	44352	$143,182	$221,760	$364,942	$6
43	1413.78	10.19	44352	$143,178	$221,760	$364,938	$4
236	1413.64	10.19	44352	$143,164	$221,760	$364,924	$14
103	1413.58	10.19	44352	$143,158	$221,760	$364,918	$6
227	1413.46	10.19	44352	$143,145	$221,760	$364,905	$13
261	1413.24	10.19	44352	$143,123	$221,760	$364,883	$22
50	1413.19	10.19	44352	$143,119	$221,760	$364,879	$4
275	1412.88	10.19	44352	$143,086	$221,760	$364,846	$32
47	1412.83	10.19	44352	$143,082	$221,760	$364,842	$4
123	1412.77	10.19	48048	$143,076	$240,240	$383,316	-$18,474

Table G.1: Equal–SKU Split Example Reserve Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
17	1412.73	10.19	48048	$143,072	$240,240	$383,312	$4
229	1412.60	10.19	48048	$143,059	$240,240	$383,299	$13
126	1412.54	10.19	48048	$143,053	$240,240	$383,293	$6
157	1412.47	10.19	48048	$143,045	$240,240	$383,285	$7
78	1412.42	10.20	48048	$143,040	$240,240	$383,280	$5
38	1412.38	10.20	48048	$143,036	$240,240	$383,276	$4
79	1412.33	10.20	48048	$143,031	$240,240	$383,271	$5
42	1412.29	10.20	48048	$143,027	$240,240	$383,267	$4
178	1412.20	10.20	48048	$143,018	$240,240	$383,258	$8
156	1412.13	10.20	48048	$143,011	$240,240	$383,251	$7
33	1412.09	10.20	48048	$143,007	$240,240	$383,247	$4
267	1411.84	10.20	48048	$142,981	$240,240	$383,221	$25
120	1411.78	10.20	48048	$142,976	$240,240	$383,216	$6
196	1411.69	10.20	48048	$142,966	$240,240	$383,206	$10
54	1411.64	10.20	48048	$142,961	$240,240	$383,201	$5
217	1411.53	10.20	48048	$142,950	$240,240	$383,190	$12
46	1411.48	10.20	48048	$142,945	$240,240	$383,185	$4
289	1410.85	10.21	48048	$142,882	$240,240	$383,122	$64
271	1410.57	10.21	51744	$142,853	$258,720	$401,573	-$18,452
24	1410.53	10.21	51744	$142,849	$258,720	$401,569	$4
276	1410.20	10.21	51744	$142,816	$258,720	$401,536	$33
144	1410.14	10.21	51744	$142,809	$258,720	$401,529	$7
131	1410.08	10.21	51744	$142,803	$258,720	$401,523	$6
176	1409.99	10.21	51744	$142,795	$258,720	$401,515	$8
77	1409.95	10.21	51744	$142,790	$258,720	$401,510	$5
3	1409.91	10.21	51744	$142,786	$258,720	$401,506	$4
226	1409.78	10.21	51744	$142,773	$258,720	$401,493	$13
268	1409.52	10.22	55440	$142,747	$277,200	$419,947	-$18,454
22	1409.48	10.22	55440	$142,743	$277,200	$419,943	$4
208	1409.38	10.22	55440	$142,732	$277,200	$419,932	$11
232	1409.24	10.22	55440	$142,719	$277,200	$419,919	$14
100	1409.19	10.22	55440	$142,713	$277,200	$419,913	$5
269	1408.93	10.22	55440	$142,686	$277,200	$419,886	$27
74	1408.88	10.22	55440	$142,681	$277,200	$419,881	$5
27	1408.84	10.22	55440	$142,677	$277,200	$419,877	$4
206	1408.73	10.22	55440	$142,667	$277,200	$419,867	$10
184	1408.65	10.22	55440	$142,658	$277,200	$419,858	$9
83	1408.60	10.22	55440	$142,653	$277,200	$419,853	$5
70	1408.55	10.22	55440	$142,648	$277,200	$419,848	$5
244	1408.39	10.22	55440	$142,632	$277,200	$419,832	$16

Appendix H

Equal–SKU Split Example Forward Data – Combined

In this appendix we present the combined data for the forward department of the equal–SKU split example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Avg. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Rows" represents the number of rows in the flow rack dedicated to the given SKU. The column labeled "Dept." represents the department in which the given SKU is located.

Table H.1: Equal–SKU Split Example Forward Data – Combined.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
1	21	7.0	7.0	2.0	6.0	11.0	12.0	17.0	1.0	0.0	2.0	NVA
2	21	2.5	1.0	4.0	3.0	4.0	3.0	1.0	3.0	1.0	1.0	VA
3	21	9.1	11.0	13.0	1.0	14.0	0.0	10.0	14.0	10.0	2.0	HY
4	21	1.9	2.0	1.0	2.0	3.0	2.0	2.0	2.0	1.0	1.0	NVA
5	21	6.8	6.0	6.0	8.0	7.0	6.0	3.0	10.0	8.0	2.0	VA
6	21	1.6	2.0	1.0	2.0	2.0	1.0	1.0	2.0	2.0	1.0	NVA
7	21	5.6	8.0	9.0	10.0	3.0	1.0	1.0	8.0	5.0	2.0	NVA
8	21	2.6	3.0	1.0	4.0	0.0	2.0	3.0	4.0	4.0	1.0	VA
9	21	5.3	1.0	2.0	10.0	6.0	3.0	2.0	9.0	9.0	2.0	NVA
10	21	1.3	1.0	2.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	VA
11	21	0.6	0.0	0.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	VA
12	22	1.9	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.0	1.0	VA
13	22	6.8	5.0	3.0	6.0	8.0	4.0	10.0	8.0	10.0	2.0	VA
14	22	2.3	4.0	3.0	4.0	1.0	1.0	3.0	2.0	0.0	1.0	NVA
15	22	1.6	1.0	3.0	1.0	1.0	3.0	2.0	0.0	2.0	1.0	NVA
16	22	9.8	11.0	15.0	13.0	6.0	5.0	11.0	13.0	4.0	2.0	NVA
17	22	6.0	1.0	9.0	11.0	0.0	9.0	1.0	9.0	8.0	2.0	HY
18	22	1.3	2.0	2.0	2.0	1.0	1.0	1.0	1.0	0.0	1.0	NVA
19	22	11.8	16.0	12.0	11.0	15.0	10.0	7.0	16.0	7.0	2.0	NVA
20	22	1.5	0.0	0.0	2.0	2.0	3.0	3.0	1.0	1.0	1.0	VA
21	22	3.4	5.0	4.0	2.0	2.0	4.0	1.0	2.0	7.0	1.0	NVA
22	22	10.1	3.0	4.0	15.0	11.0	14.0	9.0	12.0	13.0	2.0	HY
23	22	3.5	5.0	1.0	4.0	2.0	5.0	0.0	8.0	3.0	1.0	VA
24	22	8.9	15.0	6.0	17.0	1.0	11.0	15.0	5.0	1.0	2.0	HY
25	22	5.5	5.0	7.0	0.0	3.0	6.0	9.0	9.0	5.0	1.0	NVA
26	23	4.1	5.0	1.0	7.0	2.0	3.0	4.0	7.0	4.0	1.0	NVA
27	23	10.6	17.0	5.0	12.0	15.0	5.0	15.0	10.0	6.0	2.0	HY
28	23	1.5	2.0	0.0	1.0	1.0	3.0	2.0	1.0	2.0	1.0	NVA
29	23	4.4	5.0	6.0	2.0	6.0	6.0	5.0	4.0	1.0	1.0	HY
30	23	1.0	1.0	0.0	1.0	1.0	2.0	2.0	1.0	0.0	1.0	HY
31	23	9.4	7.0	7.0	10.0	0.0	8.0	14.0	17.0	12.0	2.0	VA
32	23	10.4	16.0	18.0	14.0	2.0	7.0	5.0	9.0	12.0	2.0	VA
33	23	7.3	2.0	6.0	3.0	1.0	0.0	16.0	16.0	14.0	2.0	HY
34	23	1.1	2.0	1.0	2.0	0.0	1.0	1.0	1.0	1.0	1.0	VA
35	23	3.3	7.0	1.0	2.0	4.0	1.0	1.0	6.0	4.0	1.0	HY
36	23	0.9	2.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	VA
37	23	4.5	6.0	1.0	2.0	1.0	2.0	16.0	2.0	6.0	2.0	NVA
38	23	7.0	13.0	2.0	0.0	2.0	11.0	10.0	15.0	3.0	2.0	HY
39	23	9.1	11.0	0.0	5.0	16.0	9.0	9.0	6.0	17.0	2.0	VA
40	24	0.9	1.0	1.0	2.0	0.0	1.0	0.0	1.0	1.0	1.0	VA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
41	24	8.8	12.0	11.0	11.0	7.0	5.0	10.0	9.0	5.0	2.0	VA
42	24	7.4	12.0	9.0	9.0	0.0	13.0	10.0	5.0	1.0	2.0	HY
43	24	5.1	6.0	13.0	5.0	3.0	1.0	6.0	1.0	6.0	2.0	HY
44	24	12.6	8.0	16.0	14.0	3.0	17.0	19.0	6.0	18.0	3.0	NVA
45	24	1.1	0.0	1.0	1.0	2.0	1.0	1.0	1.0	2.0	1.0	NVA
46	24	8.9	9.0	5.0	11.0	4.0	12.0	8.0	10.0	12.0	2.0	HY
47	24	6.0	8.0	2.0	5.0	9.0	9.0	5.0	7.0	3.0	1.0	HY
48	24	2.5	2.0	4.0	1.0	2.0	2.0	3.0	3.0	3.0	1.0	VA
49	24	2.4	4.0	4.0	3.0	1.0	3.0	1.0	2.0	1.0	1.0	VA
50	24	5.8	7.0	5.0	8.0	3.0	4.0	5.0	5.0	9.0	1.0	HY
51	24	3.1	0.0	6.0	4.0	5.0	3.0	3.0	2.0	2.0	1.0	NVA
52	25	1.0	0.0	1.0	2.0	1.0	1.0	2.0	0.0	1.0	1.0	VA
53	25	9.0	11.0	13.0	13.0	0.0	12.0	10.0	10.0	3.0	2.0	NVA
54	25	8.4	11.0	10.0	6.0	10.0	0.0	11.0	8.0	11.0	2.0	HY
55	25	8.9	6.0	12.0	16.0	17.0	7.0	7.0	2.0	4.0	2.0	VA
56	25	9.6	15.0	11.0	11.0	7.0	10.0	7.0	6.0	10.0	2.0	VA
57	25	6.5	9.0	16.0	6.0	1.0	6.0	5.0	5.0	4.0	2.0	VA
58	25	10.5	18.0	6.0	5.0	19.0	14.0	5.0	1.0	16.0	3.0	NVA
59	25	3.4	2.0	2.0	2.0	9.0	1.0	8.0	2.0	1.0	1.0	HY
60	25	3.9	4.0	1.0	0.0	10.0	4.0	2.0	4.0	6.0	2.0	NVA
61	25	1.3	0.0	4.0	0.0	1.0	0.0	1.0	3.0	1.0	1.0	HY
62	25	7.5	3.0	2.0	16.0	5.0	9.0	4.0	16.0	5.0	2.0	VA
63	25	7.1	7.0	3.0	13.0	5.0	6.0	12.0	5.0	6.0	2.0	NVA
64	26	2.0	1.0	1.0	2.0	4.0	1.0	3.0	3.0	1.0	1.0	HY
65	26	3.9	2.0	3.0	12.0	5.0	6.0	2.0	1.0	0.0	2.0	VA
66	26	5.9	5.0	8.0	6.0	7.0	7.0	1.0	4.0	9.0	1.0	NVA
67	26	4.1	1.0	7.0	4.0	5.0	2.0	3.0	6.0	5.0	1.0	VA
68	26	5.5	3.0	7.0	5.0	9.0	3.0	5.0	7.0	5.0	1.0	NVA
69	26	3.1	0.0	1.0	4.0	5.0	5.0	3.0	3.0	4.0	1.0	NVA
70	26	13.3	12.0	16.0	20.0	0.0	20.0	21.0	1.0	16.0	3.0	HY
71	26	10.0	8.0	17.0	11.0	8.0	6.0	1.0	13.0	16.0	2.0	NVA
72	26	8.3	4.0	3.0	8.0	7.0	11.0	2.0	15.0	16.0	2.0	VA
73	26	4.1	4.0	5.0	2.0	5.0	4.0	4.0	6.0	3.0	1.0	HY
74	27	12.3	14.0	4.0	11.0	18.0	16.0	15.0	15.0	5.0	2.0	HY
75	27	2.6	3.0	0.0	3.0	3.0	3.0	5.0	0.0	4.0	1.0	NVA
76	27	7.3	8.0	4.0	10.0	3.0	0.0	1.0	23.0	9.0	3.0	NVA
77	27	11.6	16.0	17.0	2.0	13.0	15.0	4.0	11.0	15.0	2.0	HY
78	27	7.9	9.0	10.0	1.0	9.0	9.0	4.0	7.0	14.0	2.0	HY
79	27	8.1	10.0	6.0	0.0	9.0	3.0	14.0	9.0	14.0	2.0	HY
80	27	8.5	9.0	11.0	12.0	17.0	6.0	0.0	13.0	0.0	2.0	VA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
81	27	2.4	4.0	1.0	5.0	2.0	1.0	2.0	3.0	1.0	1.0	NVA
82	27	11.3	11.0	13.0	14.0	13.0	6.0	13.0	13.0	7.0	2.0	NVA
83	28	13.8	21.0	16.0	19.0	10.0	17.0	14.0	0.0	13.0	3.0	HY
84	28	8.4	13.0	1.0	12.0	8.0	6.0	7.0	12.0	8.0	2.0	NVA
85	28	3.8	2.0	0.0	8.0	4.0	0.0	10.0	1.0	5.0	2.0	VA
86	28	8.6	2.0	10.0	5.0	17.0	10.0	13.0	4.0	8.0	2.0	NVA
87	28	2.0	0.0	2.0	3.0	3.0	1.0	3.0	4.0	0.0	1.0	NVA
88	28	5.0	6.0	3.0	11.0	0.0	1.0	3.0	2.0	14.0	2.0	VA
89	28	0.8	3.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	NVA
90	28	7.5	11.0	9.0	3.0	1.0	12.0	14.0	6.0	4.0	2.0	NVA
91	28	10.8	11.0	1.0	15.0	16.0	19.0	1.0	12.0	11.0	3.0	NVA
92	29	11.6	9.0	13.0	15.0	19.0	8.0	4.0	7.0	18.0	3.0	NVA
93	29	10.3	3.0	13.0	13.0	14.0	1.0	7.0	16.0	15.0	2.0	VA
94	29	5.1	3.0	4.0	9.0	4.0	1.0	6.0	8.0	6.0	1.0	HY
95	29	10.4	13.0	7.0	2.0	3.0	20.0	20.0	9.0	9.0	3.0	NVA
96	29	11.1	10.0	16.0	18.0	6.0	17.0	13.0	2.0	7.0	2.0	NVA
97	29	11.1	9.0	5.0	2.0	10.0	15.0	17.0	19.0	12.0	3.0	NVA
98	29	3.3	5.0	5.0	4.0	2.0	0.0	6.0	4.0	0.0	1.0	HY
99	29	5.1	5.0	7.0	0.0	9.0	2.0	5.0	3.0	10.0	2.0	NVA
100	29	13.4	24.0	4.0	20.0	8.0	13.0	12.0	18.0	8.0	3.0	HY
101	30	7.0	9.0	6.0	10.0	1.0	13.0	13.0	1.0	3.0	2.0	VA
102	30	7.5	1.0	6.0	10.0	11.0	5.0	8.0	7.0	12.0	2.0	VA
103	30	6.5	12.0	6.0	1.0	7.0	12.0	0.0	9.0	5.0	2.0	HY
104	30	7.5	8.0	9.0	1.0	7.0	11.0	6.0	10.0	8.0	2.0	NVA
105	30	5.3	6.0	6.0	7.0	2.0	8.0	4.0	4.0	5.0	1.0	HY
106	30	2.3	3.0	1.0	3.0	2.0	2.0	2.0	1.0	4.0	1.0	VA
107	30	1.5	4.0	1.0	1.0	2.0	1.0	1.0	0.0	2.0	1.0	NVA
108	31	7.0	5.0	6.0	7.0	7.0	5.0	5.0	15.0	6.0	2.0	NVA
109	31	1.0	2.0	1.0	1.0	1.0	0.0	2.0	0.0	1.0	1.0	NVA
110	31	11.6	5.0	20.0	18.0	3.0	15.0	15.0	9.0	8.0	3.0	VA
111	31	7.4	5.0	5.0	2.0	14.0	4.0	10.0	6.0	13.0	2.0	NVA
112	31	11.0	10.0	6.0	0.0	6.0	21.0	15.0	12.0	18.0	3.0	VA
113	31	9.9	10.0	7.0	11.0	16.0	12.0	10.0	10.0	3.0	2.0	VA
114	31	2.4	3.0	0.0	1.0	5.0	2.0	1.0	2.0	5.0	1.0	NVA
115	32	0.6	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	NVA
116	32	6.5	8.0	5.0	10.0	3.0	9.0	2.0	7.0	8.0	2.0	HY
117	32	10.3	8.0	13.0	2.0	15.0	17.0	2.0	24.0	1.0	3.0	NVA
118	32	10.1	0.0	10.0	5.0	5.0	22.0	19.0	7.0	13.0	3.0	VA
119	32	3.6	5.0	1.0	8.0	0.0	4.0	2.0	3.0	6.0	1.0	VA
120	32	10.4	7.0	7.0	13.0	6.0	2.0	14.0	17.0	17.0	2.0	HY

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
121	32	6.5	2.0	3.0	10.0	10.0	10.0	4.0	4.0	9.0	2.0	VA
122	33	8.5	21.0	0.0	15.0	2.0	5.0	18.0	3.0	4.0	3.0	NVA
123	33	8.9	12.0	12.0	1.0	4.0	7.0	26.0	3.0	6.0	3.0	HY
124	33	6.3	4.0	1.0	11.0	3.0	3.0	13.0	8.0	7.0	2.0	HY
125	33	9.1	9.0	15.0	14.0	13.0	9.0	8.0	3.0	2.0	2.0	NVA
126	33	9.4	16.0	15.0	15.0	7.0	11.0	3.0	7.0	1.0	2.0	HY
127	33	1.3	1.0	1.0	3.0	0.0	1.0	0.0	3.0	1.0	1.0	NVA
128	34	11.1	6.0	8.0	14.0	14.0	11.0	15.0	0.0	21.0	3.0	VA
129	34	4.6	1.0	7.0	2.0	3.0	9.0	5.0	6.0	4.0	1.0	VA
130	34	7.1	8.0	13.0	12.0	6.0	1.0	4.0	6.0	7.0	2.0	HY
131	34	14.0	2.0	20.0	14.0	27.0	16.0	1.0	24.0	8.0	3.0	HY
132	34	6.5	3.0	9.0	8.0	6.0	5.0	9.0	7.0	5.0	1.0	HY
133	34	1.4	1.0	1.0	3.0	3.0	1.0	1.0	1.0	0.0	1.0	NVA
134	35	2.9	0.0	3.0	3.0	4.0	2.0	4.0	3.0	4.0	1.0	HY
135	35	14.0	12.0	27.0	15.0	7.0	4.0	24.0	20.0	3.0	3.0	VA
136	35	8.4	4.0	16.0	14.0	15.0	0.0	6.0	12.0	0.0	2.0	NVA
137	35	16.1	25.0	16.0	3.0	21.0	20.0	15.0	3.0	26.0	3.0	VA
138	35	6.8	2.0	6.0	12.0	9.0	6.0	3.0	12.0	4.0	2.0	NVA
139	36	9.5	11.0	4.0	9.0	11.0	7.0	5.0	12.0	17.0	2.0	VA
140	36	1.5	1.0	2.0	2.0	0.0	3.0	2.0	0.0	2.0	1.0	VA
141	36	1.0	1.0	1.0	2.0	0.0	1.0	1.0	1.0	1.0	1.0	VA
142	36	15.1	17.0	13.0	12.0	13.0	11.0	19.0	28.0	8.0	4.0	VA
143	36	2.5	2.0	4.0	2.0	4.0	4.0	2.0	1.0	1.0	1.0	VA
144	37	14.9	8.0	17.0	30.0	8.0	27.0	9.0	5.0	15.0	4.0	HY
145	37	2.8	0.0	2.0	7.0	1.0	0.0	4.0	1.0	7.0	1.0	NVA
146	37	5.8	0.0	3.0	1.0	15.0	13.0	10.0	2.0	2.0	2.0	HY
147	37	4.8	4.0	7.0	6.0	2.0	2.0	4.0	8.0	5.0	1.0	HY
148	37	11.9	20.0	3.0	8.0	21.0	23.0	1.0	4.0	15.0	3.0	VA
149	38	13.0	4.0	18.0	14.0	16.0	14.0	21.0	8.0	9.0	3.0	VA
150	38	4.8	2.0	9.0	8.0	4.0	4.0	6.0	2.0	3.0	1.0	VA
151	38	0.5	0.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	NVA
152	38	7.1	5.0	3.0	3.0	13.0	12.0	13.0	1.0	7.0	2.0	NVA
153	38	5.0	11.0	6.0	3.0	1.0	2.0	2.0	3.0	12.0	2.0	NVA
154	39	0.9	2.0	0.0	1.0	0.0	1.0	0.0	1.0	2.0	1.0	NVA
155	39	3.4	6.0	0.0	0.0	6.0	4.0	1.0	6.0	4.0	1.0	HY
156	39	12.1	12.0	9.0	18.0	21.0	6.0	21.0	2.0	8.0	3.0	HY
157	39	11.1	13.0	7.0	15.0	12.0	10.0	12.0	14.0	6.0	2.0	HY
158	40	5.5	4.0	6.0	3.0	3.0	9.0	8.0	9.0	2.0	1.0	HY
159	40	1.4	1.0	2.0	2.0	0.0	3.0	2.0	1.0	0.0	1.0	VA
160	40	10.8	11.0	25.0	8.0	9.0	3.0	16.0	9.0	5.0	3.0	NVA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
161	40	17.9	9.0	28.0	0.0	25.0	3.0	21.0	28.0	29.0	4.0	NVA
162	41	0.9	1.0	1.0	2.0	1.0	1.0	0.0	1.0	0.0	1.0	NVA
163	41	10.0	3.0	15.0	14.0	9.0	5.0	11.0	10.0	13.0	2.0	NVA
164	41	2.5	3.0	1.0	5.0	5.0	2.0	1.0	3.0	0.0	1.0	NVA
165	41	2.6	1.0	5.0	0.0	3.0	2.0	3.0	6.0	1.0	1.0	VA
166	42	6.6	5.0	4.0	6.0	6.0	11.0	9.0	2.0	10.0	2.0	VA
167	42	4.5	2.0	4.0	2.0	4.0	6.0	4.0	7.0	7.0	1.0	HY
168	42	1.6	4.0	0.0	2.0	1.0	3.0	1.0	1.0	1.0	1.0	VA
169	42	3.1	1.0	7.0	0.0	5.0	6.0	0.0	3.0	3.0	1.0	VA
170	43	2.8	1.0	2.0	5.0	3.0	0.0	1.0	2.0	8.0	1.0	NVA
171	43	0.9	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	VA
172	43	4.6	5.0	4.0	7.0	4.0	2.0	6.0	3.0	6.0	1.0	VA
173	44	1.9	1.0	3.0	0.0	3.0	1.0	1.0	3.0	3.0	1.0	VA
174	44	9.1	10.0	15.0	7.0	6.0	14.0	15.0	2.0	4.0	2.0	NVA
175	44	12.0	2.0	4.0	18.0	10.0	0.0	28.0	9.0	25.0	4.0	NVA
176	44	18.3	26.0	23.0	3.0	6.0	12.0	26.0	25.0	25.0	3.0	HY
177	45	7.1	3.0	2.0	0.0	9.0	9.0	12.0	9.0	13.0	2.0	HY
178	45	13.9	17.0	13.0	20.0	16.0	16.0	9.0	3.0	17.0	3.0	HY
179	45	8.8	17.0	15.0	0.0	16.0	4.0	3.0	4.0	11.0	2.0	HY
180	46	5.8	6.0	11.0	11.0	1.0	3.0	0.0	10.0	4.0	2.0	NVA
181	46	1.3	1.0	1.0	2.0	0.0	1.0	1.0	2.0	2.0	1.0	NVA
182	46	12.6	5.0	14.0	9.0	12.0	12.0	20.0	15.0	14.0	3.0	VA
183	47	0.9	0.0	1.0	1.0	0.0	1.0	1.0	2.0	1.0	1.0	HY
184	47	23.9	30.0	21.0	30.0	7.0	11.0	28.0	28.0	36.0	4.0	HY
185	47	6.8	1.0	0.0	6.0	7.0	11.0	11.0	10.0	8.0	2.0	HY
186	48	21.4	24.0	8.0	21.0	11.0	28.0	25.0	27.0	27.0	4.0	NVA
187	48	17.3	19.0	32.0	5.0	29.0	19.0	0.0	17.0	17.0	4.0	NVA
188	49	9.4	5.0	14.0	21.0	5.0	9.0	12.0	8.0	1.0	3.0	HY
189	49	18.1	22.0	16.0	6.0	35.0	21.0	3.0	35.0	7.0	4.0	VA
190	49	20.4	24.0	25.0	21.0	7.0	25.0	24.0	19.0	18.0	3.0	VA
191	50	21.4	39.0	9.0	21.0	18.0	11.0	7.0	33.0	33.0	5.0	VA
192	50	11.8	25.0	1.0	13.0	2.0	24.0	10.0	16.0	3.0	3.0	VA
193	50	7.5	0.0	15.0	12.0	13.0	3.0	5.0	9.0	3.0	2.0	NVA
194	51	9.4	17.0	11.0	9.0	7.0	5.0	9.0	11.0	6.0	2.0	HY
195	51	1.0	1.0	1.0	0.0	1.0	1.0	2.0	1.0	1.0	1.0	VA
196	52	17.1	27.0	16.0	29.0	10.0	7.0	5.0	12.0	31.0	4.0	HY
197	52	12.8	5.0	15.0	8.0	12.0	9.0	19.0	19.0	15.0	3.0	VA
198	53	26.0	27.0	25.0	31.0	13.0	35.0	11.0	32.0	34.0	4.0	VA
199	53	10.4	3.0	6.0	7.0	10.0	2.0	12.0	25.0	18.0	3.0	HY
200	53	15.4	4.0	27.0	12.0	26.0	3.0	3.0	23.0	25.0	3.0	VA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
201	54	11.4	20.0	5.0	17.0	6.0	7.0	18.0	10.0	8.0	3.0	VA
202	54	6.9	5.0	13.0	7.0	9.0	12.0	1.0	7.0	1.0	2.0	NVA
203	55	12.5	2.0	7.0	23.0	21.0	1.0	6.0	24.0	16.0	3.0	NVA
204	55	29.4	36.0	27.0	25.0	19.0	33.0	34.0	38.0	23.0	5.0	NVA
205	56	4.1	5.0	1.0	6.0	1.0	10.0	5.0	3.0	2.0	2.0	NVA
206	56	26.3	6.0	17.0	39.0	45.0	27.0	22.0	42.0	12.0	5.0	HY
207	57	15.9	14.0	11.0	17.0	21.0	24.0	12.0	14.0	14.0	3.0	NVA
208	57	25.8	7.0	43.0	32.0	12.0	38.0	28.0	4.0	42.0	5.0	HY
209	58	24.5	23.0	27.0	43.0	12.0	3.0	42.0	34.0	12.0	5.0	NVA
210	59	11.1	18.0	15.0	8.0	10.0	3.0	14.0	20.0	1.0	3.0	HY
211	59	9.4	13.0	5.0	11.0	3.0	11.0	5.0	11.0	16.0	2.0	VA
212	60	16.4	22.0	20.0	10.0	20.0	11.0	22.0	4.0	22.0	3.0	VA
213	60	9.5	19.0	13.0	3.0	14.0	3.0	3.0	10.0	11.0	3.0	VA
214	61	22.3	40.0	39.0	31.0	9.0	31.0	4.0	21.0	3.0	5.0	VA
215	61	1.4	1.0	0.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	HY
216	62	21.4	23.0	36.0	4.0	0.0	44.0	31.0	29.0	4.0	5.0	NVA
217	63	22.5	27.0	13.0	15.0	20.0	31.0	31.0	16.0	27.0	4.0	HY
218	63	24.1	29.0	5.0	18.0	32.0	31.0	28.0	32.0	18.0	4.0	VA
219	64	1.1	0.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	HY
220	65	14.5	21.0	9.0	12.0	10.0	16.0	19.0	16.0	13.0	3.0	VA
221	65	10.0	5.0	10.0	11.0	22.0	12.0	13.0	0.0	7.0	3.0	HY
222	66	10.8	11.0	17.0	14.0	1.0	15.0	1.0	13.0	14.0	2.0	VA
223	67	9.3	2.0	4.0	15.0	15.0	6.0	6.0	13.0	13.0	2.0	HY
224	68	4.8	5.0	4.0	7.0	1.0	5.0	8.0	4.0	4.0	1.0	NVA
225	68	7.1	12.0	10.0	8.0	5.0	1.0	3.0	8.0	10.0	2.0	VA
226	69	29.3	45.0	17.0	30.0	37.0	29.0	13.0	19.0	44.0	5.0	HY
227	70	16.0	9.0	20.0	17.0	9.0	18.0	24.0	11.0	20.0	3.0	HY
228	71	9.1	8.0	6.0	11.0	2.0	4.0	18.0	10.0	14.0	2.0	NVA
229	72	19.5	33.0	5.0	11.0	10.0	18.0	37.0	33.0	9.0	5.0	HY
230	73	24.5	22.0	45.0	22.0	40.0	26.0	6.0	26.0	9.0	5.0	NVA
231	73	15.1	24.0	6.0	23.0	6.0	9.0	16.0	27.0	10.0	3.0	VA
232	74	29.3	24.0	33.0	45.0	11.0	33.0	45.0	23.0	20.0	5.0	HY
233	75	8.6	9.0	12.0	6.0	7.0	14.0	10.0	8.0	3.0	2.0	NVA
234	76	23.1	44.0	9.0	30.0	30.0	28.0	27.0	9.0	8.0	5.0	NVA
235	77	24.0	2.0	6.0	28.0	20.0	41.0	39.0	29.0	27.0	5.0	VA
236	78	17.3	27.0	23.0	26.0	25.0	14.0	12.0	9.0	2.0	3.0	HY
237	79	10.9	11.0	12.0	16.0	12.0	9.0	10.0	9.0	8.0	2.0	VA
238	80	2.1	2.0	1.0	2.0	2.0	4.0	1.0	2.0	3.0	1.0	NVA
239	82	31.4	21.0	30.0	28.0	45.0	38.0	14.0	45.0	30.0	5.0	VA
240	83	13.1	21.0	18.0	15.0	4.0	16.0	27.0	1.0	3.0	3.0	VA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
241	84	17.0	28.0	19.0	13.0	34.0	23.0	1.0	17.0	1.0	4.0	NVA
242	85	9.1	14.0	8.0	15.0	3.0	9.0	12.0	8.0	4.0	2.0	VA
243	86	10.4	12.0	0.0	20.0	8.0	4.0	10.0	15.0	14.0	3.0	HY
244	88	38.9	45.0	39.0	45.0	45.0	45.0	25.0	45.0	22.0	5.0	HY
245	89	34.9	26.0	45.0	40.0	38.0	33.0	24.0	29.0	44.0	5.0	VA
246	91	0.9	0.0	0.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	VA
247	92	18.9	15.0	24.0	6.0	27.0	22.0	24.0	27.0	6.0	3.0	HY
248	94	16.9	28.0	32.0	18.0	2.0	19.0	3.0	23.0	10.0	4.0	HY
249	95	10.6	11.0	1.0	14.0	7.0	11.0	5.0	21.0	15.0	3.0	NVA
250	97	35.8	45.0	8.0	45.0	45.0	43.0	10.0	45.0	45.0	5.0	NVA
251	98	28.4	0.0	44.0	22.0	37.0	10.0	43.0	26.0	45.0	5.0	VA
252	100	20.9	45.0	15.0	4.0	9.0	39.0	17.0	1.0	37.0	5.0	NVA
253	102	36.4	43.0	15.0	45.0	32.0	45.0	26.0	40.0	45.0	5.0	NVA
254	104	18.3	9.0	2.0	27.0	7.0	26.0	22.0	27.0	26.0	3.0	VA
255	106	3.6	6.0	1.0	1.0	4.0	2.0	5.0	6.0	4.0	1.0	HY
256	108	38.9	39.0	45.0	45.0	45.0	45.0	32.0	22.0	38.0	5.0	NVA
257	110	32.8	45.0	12.0	13.0	45.0	45.0	32.0	34.0	36.0	5.0	VA
258	112	34.3	45.0	32.0	4.0	45.0	45.0	45.0	39.0	19.0	5.0	NVA
259	114	18.3	17.0	24.0	3.0	19.0	16.0	23.0	19.0	25.0	3.0	VA
260	117	12.6	3.0	17.0	13.0	18.0	12.0	15.0	5.0	18.0	2.0	VA
261	119	26.9	25.0	34.0	25.0	44.0	22.0	10.0	10.0	45.0	5.0	HY
262	122	16.3	26.0	14.0	8.0	23.0	16.0	16.0	18.0	9.0	3.0	NVA
263	125	32.9	45.0	41.0	9.0	29.0	45.0	45.0	16.0	33.0	5.0	NVA
264	128	19.5	16.0	7.0	15.0	35.0	33.0	14.0	4.0	32.0	4.0	HY
265	131	14.3	12.0	14.0	16.0	16.0	20.0	17.0	14.0	5.0	3.0	HY
266	134	16.1	9.0	6.0	8.0	24.0	25.0	17.0	10.0	30.0	4.0	HY
267	138	28.5	45.0	36.0	23.0	8.0	24.0	2.0	45.0	45.0	5.0	HY
268	141	38.3	45.0	45.0	30.0	45.0	17.0	45.0	34.0	45.0	5.0	HY
269	145	39.8	45.0	45.0	35.0	13.0	45.0	45.0	45.0	45.0	5.0	HY
270	149	1.4	2.0	1.0	1.0	2.0	0.0	1.0	2.0	2.0	1.0	HY
271	154	37.6	45.0	45.0	45.0	44.0	18.0	45.0	22.0	37.0	5.0	HY
272	158	35.4	0.0	40.0	45.0	45.0	45.0	45.0	18.0	45.0	5.0	VA
273	163	16.8	12.0	14.0	23.0	7.0	23.0	25.0	23.0	7.0	3.0	HY
274	168	19.3	2.0	17.0	27.0	15.0	23.0	17.0	22.0	31.0	4.0	NVA
275	174	38.9	45.0	26.0	28.0	44.0	45.0	45.0	33.0	45.0	5.0	HY
276	180	34.4	45.0	12.0	29.0	45.0	9.0	45.0	45.0	45.0	5.0	HY
277	187	41.3	45.0	45.0	15.0	45.0	45.0	45.0	45.0	45.0	5.0	VA
278	194	21.9	41.0	45.0	20.0	9.0	17.0	0.0	23.0	20.0	5.0	HY
279	202	5.6	3.0	10.0	4.0	3.0	1.0	9.0	5.0	10.0	2.0	HY
280	210	36.1	45.0	45.0	9.0	14.0	45.0	45.0	41.0	45.0	5.0	NVA

Table H.1: Equal–SKU Split Example Forward Data – Combined *(continued)*.

			Week									
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Rows**	**Dept.**
281	219	16.1	9.0	16.0	16.0	34.0	15.0	4.0	27.0	8.0	4.0	HY
282	230	40.6	45.0	45.0	45.0	45.0	44.0	11.0	45.0	45.0	5.0	VA
283	241	9.1	8.0	22.0	2.0	13.0	4.0	1.0	11.0	12.0	3.0	HY
284	253	39.9	45.0	45.0	16.0	45.0	45.0	45.0	33.0	45.0	5.0	VA
285	267	38.6	37.0	45.0	25.0	45.0	33.0	45.0	34.0	45.0	5.0	VA
286	283	40.8	45.0	45.0	45.0	45.0	45.0	11.0	45.0	45.0	5.0	VA
287	301	32.9	45.0	45.0	16.0	45.0	25.0	45.0	0.0	42.0	5.0	HY
288	322	34.9	45.0	45.0	11.0	42.0	17.0	45.0	29.0	45.0	5.0	HY
289	346	38.1	45.0	45.0	45.0	11.0	45.0	45.0	41.0	28.0	5.0	HY
290	374	25.6	26.0	21.0	21.0	26.0	34.0	17.0	22.0	38.0	5.0	NVA
291	408	40.4	45.0	45.0	45.0	45.0	45.0	45.0	8.0	45.0	5.0	HY
292	449	36.4	30.0	45.0	45.0	27.0	45.0	45.0	45.0	9.0	5.0	HY
293	500	22.3	43.0	17.0	23.0	1.0	44.0	3.0	29.0	18.0	5.0	HY
294	566	34.4	45.0	0.0	10.0	45.0	45.0	45.0	45.0	40.0	5.0	HY
295	654	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	5.0	VA
296	778	44.3	39.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	5.0	NVA
297	968	31.9	45.0	45.0	1.0	29.0	0.0	45.0	45.0	45.0	5.0	VA
298	1300	40.4	45.0	8.0	45.0	45.0	45.0	45.0	45.0	45.0	5.0	NVA
299	2060	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	5.0	VA
300	20365	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	5.0	VA

Appendix I

Equal–SKU Split Example Forward Data – Separate

In this appendix we present the separate data for the forward department of the equal–SKU split example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Rows" represents the number of rows dedicated to the given SKU in the forward department. The column labeled "Dept." represents the department in which the given SKU is located.

Table I.1: Equal–SKU Split Example Forward Data – Separate NVA.

SKU	Demand	Rows	Dept.
3	21	2.0	HY-NVA
17	22	2.0	HY-NVA
22	22	2.0	HY-NVA
24	22	2.0	HY-NVA
27	23	2.0	HY-NVA
29	23	1.0	HY-NVA
30	23	1.0	HY-NVA
33	23	2.0	HY-NVA
35	23	1.0	HY-NVA
38	23	2.0	HY-NVA
42	24	2.0	HY-NVA
43	24	2.0	HY-NVA
46	24	2.0	HY-NVA
47	24	1.0	HY-NVA
50	24	1.0	HY-NVA
54	25	2.0	HY-NVA
59	25	1.0	HY-NVA
61	25	1.0	HY-NVA
64	26	1.0	HY-NVA

Table I.1: Equal–SKU Split Example Forward Data – Separate NVA *(continued)*.

SKU	Demand	Rows	Dept.
70	26	2.0	HY-NVA
73	26	1.0	HY-NVA
74	27	2.0	HY-NVA
77	27	2.0	HY-NVA
78	27	2.0	HY-NVA
79	27	2.0	HY-NVA
83	28	2.0	HY-NVA
94	29	1.0	HY-NVA
98	29	1.0	HY-NVA
100	29	2.0	HY-NVA
103	30	2.0	HY-NVA
105	30	1.0	HY-NVA
116	32	2.0	HY-NVA
120	32	2.0	HY-NVA
123	33	2.0	HY-NVA
124	33	2.0	HY-NVA
126	33	2.0	HY-NVA
130	34	2.0	HY-NVA
131	34	2.0	HY-NVA
132	34	1.0	HY-NVA
134	35	1.0	HY-NVA
144	37	3.0	HY-NVA
146	37	2.0	HY-NVA
147	37	1.0	HY-NVA
155	39	1.0	HY-NVA
156	39	2.0	HY-NVA
157	39	2.0	HY-NVA
158	40	1.0	HY-NVA
167	42	1.0	HY-NVA
176	44	2.0	HY-NVA
177	45	2.0	HY-NVA
178	45	2.0	HY-NVA
179	45	2.0	HY-NVA
183	47	1.0	HY-NVA
184	47	3.0	HY-NVA
185	47	2.0	HY-NVA
188	49	2.0	HY-NVA
194	51	2.0	HY-NVA
196	52	3.0	HY-NVA
199	53	2.0	HY-NVA
206	56	3.0	HY-NVA
208	57	3.0	HY-NVA
210	59	2.0	HY-NVA
215	61	1.0	HY-NVA
217	63	3.0	HY-NVA
219	64	1.0	HY-NVA
221	65	2.0	HY-NVA
223	67	2.0	HY-NVA
226	69	3.0	HY-NVA
227	70	2.0	HY-NVA
229	72	3.0	HY-NVA
232	74	3.0	HY-NVA
236	78	2.0	HY-NVA
243	86	2.0	HY-NVA
244	88	3.0	HY-NVA
247	92	2.0	HY-NVA
248	94	3.0	HY-NVA
255	106	1.0	HY-NVA
261	119	3.0	HY-NVA
264	128	3.0	HY-NVA

Table I.1: Equal–SKU Split Example Forward Data – Separate NVA *(continued)*.

SKU	Demand	Rows	Dept.
265	131	2.0	HY-NVA
266	134	3.0	HY-NVA
267	138	3.0	HY-NVA
268	141	3.0	HY-NVA
269	145	3.0	HY-NVA
270	149	1.0	HY-NVA
271	154	3.0	HY-NVA
273	163	2.0	HY-NVA
275	174	3.0	HY-NVA
276	180	3.0	HY-NVA
278	194	3.0	HY-NVA
279	202	2.0	HY-NVA
281	219	3.0	HY-NVA
283	241	2.0	HY-NVA
287	301	3.0	HY-NVA
288	322	3.0	HY-NVA
289	346	3.0	HY-NVA
291	408	3.0	HY-NVA
292	449	3.0	HY-NVA
293	500	3.0	HY-NVA
294	566	3.0	HY-NVA

Table I.2: Equal–SKU Split Example Forward Data – Separate VA.

SKU	Demand	Rows	Dept.
3	21	2.0	HY-VA
17	22	2.0	HY-VA
22	22	2.0	HY-VA
24	22	2.0	HY-VA
27	23	2.0	HY-VA
29	23	1.0	HY-VA
30	23	1.0	HY-VA
33	23	2.0	HY-VA
35	23	1.0	HY-VA
38	23	2.0	HY-VA
42	24	2.0	HY-VA
43	24	2.0	HY-VA
46	24	2.0	HY-VA
47	24	1.0	HY-VA
50	24	1.0	HY-VA
54	25	2.0	HY-VA
59	25	1.0	HY-VA
61	25	1.0	HY-VA
64	26	1.0	HY-VA
70	26	3.0	HY-VA
73	26	1.0	HY-VA
74	27	2.0	HY-VA
77	27	2.0	HY-VA
78	27	2.0	HY-VA
79	27	2.0	HY-VA
83	28	3.0	HY-VA
94	29	1.0	HY-VA
98	29	1.0	HY-VA
100	29	3.0	HY-VA
103	30	2.0	HY-VA
105	30	1.0	HY-VA
116	32	2.0	HY-VA
120	32	2.0	HY-VA
123	33	3.0	HY-VA

Table I.2: Equal–SKU Split Example Forward Data – Separate VA *(continued)*.

SKU	Demand	Rows	Dept.
124	33	2.0	HY-VA
126	33	2.0	HY-VA
130	34	2.0	HY-VA
131	34	3.0	HY-VA
132	34	1.0	HY-VA
134	35	1.0	HY-VA
144	37	3.0	HY-VA
146	37	2.0	HY-VA
147	37	1.0	HY-VA
155	39	1.0	HY-VA
156	39	3.0	HY-VA
157	39	2.0	HY-VA
158	40	1.0	HY-VA
167	42	1.0	HY-VA
176	44	3.0	HY-VA
177	45	2.0	HY-VA
178	45	3.0	HY-VA
179	45	2.0	HY-VA
183	47	1.0	HY-VA
184	47	3.0	HY-VA
185	47	2.0	HY-VA
188	49	3.0	HY-VA
194	51	2.0	HY-VA
196	52	3.0	HY-VA
199	53	3.0	HY-VA
206	56	4.0	HY-VA
208	57	4.0	HY-VA
210	59	3.0	HY-VA
215	61	1.0	HY-VA
217	63	3.0	HY-VA
219	64	1.0	HY-VA
221	65	3.0	HY-VA
223	67	2.0	HY-VA
226	69	4.0	HY-VA
227	70	3.0	HY-VA
229	72	4.0	HY-VA
232	74	4.0	HY-VA
236	78	3.0	HY-VA
243	86	3.0	HY-VA
244	88	4.0	HY-VA
247	92	3.0	HY-VA
248	94	3.0	HY-VA
255	106	1.0	HY-VA
261	119	4.0	HY-VA
264	128	3.0	HY-VA
265	131	3.0	HY-VA
266	134	3.0	HY-VA
267	138	4.0	HY-VA
268	141	4.0	HY-VA
269	145	4.0	HY-VA
270	149	1.0	HY-VA
271	154	4.0	HY-VA
273	163	3.0	HY-VA
275	174	4.0	HY-VA
276	180	4.0	HY-VA
278	194	4.0	HY-VA
279	202	2.0	HY-VA
281	219	3.0	HY-VA
283	241	3.0	HY-VA
287	301	4.0	HY-VA
288	322	4.0	HY-VA

Table I.2: Equal–SKU Split Example Forward Data – Separate VA *(continued)*.

SKU	Demand	Rows	Dept.
289	346	4.0	HY-VA
291	408	4.0	HY-VA
292	449	4.0	HY-VA
293	500	4.0	HY-VA
294	566	4.0	HY-VA

Appendix J

Simulation Results for the Initial Hybrid Equal–SKU Split Example

In this appendix we present the simulation results for the initial hybrid layout for the forward department of the equal–SKU split example. The columns labeled "NVA" represent the replication results for the NVA simulations. The columns labeled "VA" represent the replication results for the VA simulations. 1000 replications were performed for both the NVA and VA simulations.

Table J.1: Simulation Results for the Initial Hybrid Equal–SKU Split Example.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
530	538		430	438		378	488		478	486
434	534		474	384		478	538		382	334
434	386		430	382		426	438		430	536
482	432		478	586		382	436		478	438
478	384		330	536		386	384		482	384
478	382		330	384		526	488		330	384
434	334		430	334		330	386		334	334
430	386		478	436		430	436		430	436
378	386		482	436		430	436		430	382
374	334		426	334		422	334		530	436
526	436		430	386		378	384		430	384
430	386		382	486		426	334		426	436
522	434		330	334		430	384		382	436
434	436		378	334		426	588		474	334
426	436		482	382		478	386		330	486
430	434		478	536		474	384		430	434
378	434		478	486		478	436		530	384
482	438		430	384		434	384		382	436
378	486		478	484		374	488		378	538

Table J.1: Simulation Results for the Initial Hybrid Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
378	384		482	434		430	486		482	336
530	332		430	436		278	434		430	332
374	434		430	384		434	486		426	386
530	384		430	438		334	384		378	436
386	384		330	332		430	486		430	384
430	538		430	486		378	386		482	486
478	436		430	436		430	332		474	436
426	384		378	536		430	486		430	436
382	436		374	434		426	438		430	386
330	388		378	436		530	486		478	384
382	384		430	432		326	436		378	434
374	438		382	336		430	386		426	434
430	332		378	386		426	436		530	382
330	384		478	384		382	434		330	436
378	332		478	334		426	386		382	538
530	334		434	384		382	386		526	538
430	384		430	386		430	434		526	384
482	432		430	386		578	486		378	438
430	486		278	438		430	436		426	436
378	538		374	384		578	434		530	434
478	436		378	536		526	336		478	436
426	284		330	436		478	384		430	386
478	436		378	488		382	436		378	336
382	486		478	434		426	434		426	538
426	332		378	384		526	536		426	284
482	484		382	488		430	382		530	334
374	334		478	486		426	436		430	334
478	386		526	384		278	434		526	384
382	382		478	384		282	386		430	486
430	486		474	484		330	538		434	486
326	436		426	436		530	434		382	384
530	434		478	488		526	334		430	284
330	436		326	332		478	334		430	486
430	536		478	538		426	536		378	384
478	386		430	538		430	384		430	336
478	536		430	386		430	384		422	588
434	334		430	282		482	434		430	436
530	486		526	334		478	484		382	434
478	386		482	384		430	438		426	384
482	384		482	436		378	536		382	436
482	436		378	282		382	588		382	436
526	436		478	438		426	332		330	336
478	382		530	538		382	436		430	382
426	588		478	386		330	284		378	536
378	386		478	486		378	384		426	334
382	484		526	386		530	386		478	334
478	384		426	436		382	436		430	538
478	488		426	484		478	384		478	386
378	438		482	536		430	486		474	436
434	438		378	434		482	436		378	486
382	436		426	436		378	434		578	434
426	434		478	334		478	436		430	386
382	384		330	436		430	488		530	534
326	386		478	434		430	436		430	386
378	434		382	538		382	332		478	538
482	484		430	434		578	536		378	386
382	436		526	436		430	382		478	384
282	434		430	538		326	538		382	434
430	386		430	434		386	386		378	386
478	334		330	434		478	334		430	384

Table J.1: Simulation Results for the Initial Hybrid Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
478	488		474	384		426	334		378	488
430	384		378	332		430	436		530	386
378	384		382	436		430	434		382	332
426	334		378	486		478	336		430	386
482	436		422	436		382	436		430	434
430	536		378	486		430	434		478	434
482	284		478	434		526	436		430	436
478	384		382	436		378	434		526	488
478	334		478	386		434	334		334	386
422	388		578	386		430	386		526	334
430	384		330	334		478	282		478	386
434	486		426	334		522	384		474	434
530	336		430	484		474	386		430	384
382	486		430	384		478	336		382	436
482	484		278	334		430	386		530	386
478	386		482	436		430	282		378	284
426	386		426	384		430	332		578	386
278	486		482	384		430	432		430	436
530	486		530	438		478	434		426	382
530	436		330	384		330	334		426	436
382	382		430	384		426	332		482	486
426	334		330	438		430	432		430	336
422	384		430	436		478	282		478	384
378	438		426	384		526	436		478	436
430	436		430	434		430	538		382	336
430	384		526	386		430	386		378	486
526	436		378	434		378	438		334	436
434	386		482	486		278	384		382	436
430	488		478	436		326	384		426	386
326	284		434	486		530	484		434	384
426	436		482	488		526	434		326	438
330	436		478	332		478	436		478	488
574	538		430	586		478	436		474	384
430	536		474	334		426	486		478	538
330	488		430	436		330	434		330	436
430	386		386	382		382	384		478	434
330	388		482	386		334	384		478	482
378	384		530	488		426	438		482	438
378	332		478	386		478	436		330	434
478	436		478	436		474	438		530	384
478	438		422	386		426	384		378	434
526	436		378	332		378	438		430	436
430	436		430	334		278	282		426	436
430	384		530	436		478	436		382	384
430	436		374	282		378	334		378	438
478	334		430	534		430	534		430	436
330	434		482	484		482	284		430	384
426	384		374	538		430	386		422	386
478	438		478	334		278	486		378	282
378	386		430	488		474	486		426	332
478	382		382	488		426	436		482	488
482	336		430	438		478	486		478	334
482	488		430	284		482	436		434	486
426	486		382	482		478	538		578	488
378	438		426	382		430	434		434	434
426	486		382	486		578	486		382	434
526	436		526	386		378	386		426	486
378	386		530	486		426	336		426	384
526	436		430	382		470	384		426	536
434	386		378	386		526	484		574	436

Table J.1: Simulation Results for the Initial Hybrid Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
430	336		478	434		478	438		430	484
526	436		330	334		378	434		478	436
482	282		430	334		574	432		530	588
530	436		386	386		482	436		474	332
382	434		426	486		430	336		430	438
426	436		526	386		530	434		426	436
430	386		474	386		530	334		430	486
434	384		430	386		430	486		378	384
430	438		430	488		478	538		382	436
430	432		526	382		426	436		530	332
382	486		378	384		430	486		526	386
478	488		330	438		526	486		326	436
478	486		526	334		330	434		522	384
330	436		430	436		426	488		378	332
382	384		430	386		426	486		378	486
378	386		426	384		330	386		430	384
430	336		430	388		530	386		478	436
378	436		422	336		434	384		378	436
282	486		470	486		478	438		378	436
378	384		378	434		578	384		430	386
482	436		526	386		526	438		378	588
478	486		426	436		482	536		382	436
378	384		374	434		382	434		434	588
478	436		430	384		530	386		434	384
430	384		378	488		430	386		478	436
474	488		382	434		378	386		378	488
434	436		478	384		282	434		430	436
474	436		426	332		426	436		430	486
430	384		378	282		378	384		426	384
378	486		426	386		430	282		478	486
430	386		282	336		378	436		430	486
530	386		526	486		378	486		482	384
378	436		378	438		434	434		482	486
378	488		382	436		434	438		426	384
478	436		282	386		378	436		378	386
378	436		330	436		426	436		330	384
278	384		378	436		434	332		526	386
478	486		426	436		382	282		478	336
530	486		478	384		478	438		430	434
478	334		378	538		478	488		530	282
430	336		430	482		430	434		426	384
382	384		430	436		378	484		482	336
522	484		430	384		430	334		330	488
526	284		330	334		482	382		378	588
526	434		334	488		374	384		482	538
474	386		574	384		482	488		326	386
478	336		430	384		330	436		382	332
378	386		478	434		378	488		430	436
378	284		474	486		430	538		478	486
474	486		378	436		422	486		530	386
530	334		426	436		430	434		526	436
326	386		530	486		382	434		478	538
578	486		278	384		482	332		430	434
474	538		374	386		434	382		482	332
430	384		478	536		434	538		382	436
478	336		330	434		382	438		378	334
478	436		382	384		482	486		278	386
434	486		478	486		378	484		530	386
382	282		526	484		378	386		430	284
382	434		478	586		430	488		482	538

Table J.1: Simulation Results for the Initial Hybrid Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
430	436		478	488		478	336		378	386
482	436		334	486		278	386		474	334
530	384		482	536		478	432		426	282
474	384		482	488		330	388		422	536
378	334		430	332		378	486		426	434
426	384		430	438		430	484		526	436
474	434		430	488		326	434		482	334
530	486		478	332		526	436		430	538
430	382		430	384		374	382		430	436
430	386		530	386		530	536		482	486
482	434		478	386		478	438		330	436
478	386		382	436		326	386		430	434
326	386		530	386		430	436		330	538
478	434		430	538		374	488		482	436
526	486		526	488		430	436		382	388
430	436		382	488		482	436		578	488
430	486		478	486		330	334		482	486
478	384		330	282		330	382		578	436
482	486		478	486		578	384		478	488
426	336		430	386		378	484		378	384
482	384		530	336		426	436		382	386
386	384		382	434		434	488		378	538
478	436		430	386		530	334		382	386
478	386		430	334		426	334		374	386
482	382		478	334		382	488		382	386
430	434		334	384		530	434		482	382
426	484		482	588		434	386		382	486
378	434		374	486		430	384		378	484
434	434		430	434		426	434		526	284
478	538		482	386		378	282		526	486
434	538		330	486		330	382		278	332
278	334		426	384		326	436		382	384
430	332		430	384		430	384		378	538
278	384		426	384		382	334		378	334
426	434		430	434		434	436		478	436
482	436		426	336		526	386		430	384
478	488		382	436		378	488		430	436
530	486		426	384		430	386		478	332
430	486		378	388		430	434		330	334
382	386		330	386		478	232		330	334
526	488		430	386		378	486		434	434
430	538		482	384		426	536		378	386
430	386		530	386		574	436		478	486
430	432		426	486		530	436		430	436
478	382		330	384		382	386		530	382
530	438		330	334		430	384		530	384
474	486		430	434		474	436		382	386
578	436		482	436		378	538		330	484
430	486		530	232		430	488		378	336
482	538		530	486		478	486		478	436
478	386		430	436		378	438		482	436

Appendix K

Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example

In this appendix we present the simulation results for the hybrid tradeoff layout for the forward department of the equal–SKU split example. The columns labeled "NVA" represent the replication results for the NVA simulations. The columns labeled "VA" represent the replication results for the VA simulations. 1000 replications were performed for both the NVA and VA simulations.

Table K.1: Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
478	436		378	536		374	384		430	384
426	434		430	484		430	436		578	588
378	334		482	384		482	384		278	384
478	488		430	386		430	384		478	484
526	384		430	486		434	436		378	434
474	436		434	486		530	384		378	488
526	436		430	386		530	384		426	384
430	486		326	484		434	438		530	438
482	432		326	386		426	486		478	434
330	484		430	436		378	434		474	382
482	384		374	386		530	434		478	384
482	588		426	434		426	386		478	332
422	486		430	282		382	384		378	384
434	434		382	334		426	482		430	488
378	282		530	332		482	284		382	486
382	336		278	436		430	436		434	334
426	334		374	386		426	332		478	436
474	434		382	384		574	436		430	436

Table K.1: Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
478	384		478	436		578	436		278	436
526	434		478	436		374	386		530	434
478	436		378	434		478	436		374	384
478	538		530	434		482	434		478	386
426	436		382	488		378	334		378	436
430	334		578	436		530	434		382	336
430	384		478	384		382	488		378	386
430	386		378	384		434	382		474	384
334	386		434	382		474	438		482	382
530	438		526	436		426	436		330	436
530	386		378	382		430	484		426	486
378	386		422	438		378	432		378	334
482	386		278	386		430	488		430	488
478	488		330	434		430	334		482	436
430	336		330	386		378	384		482	336
382	386		482	434		526	438		378	434
478	488		330	488		478	488		474	284
426	436		382	386		430	434		482	384
426	486		578	436		482	436		526	436
378	386		426	336		578	488		430	484
474	436		378	486		378	388		526	336
426	334		430	436		378	382		482	434
478	386		326	486		430	436		378	436
430	486		426	486		426	488		378	436
430	436		330	384		426	386		526	434
426	486		474	436		526	488		474	488
430	336		430	282		430	436		382	436
374	436		478	438		426	282		382	486
430	436		430	486		382	384		434	384
482	282		526	436		382	488		530	486
578	282		478	332		334	384		482	334
378	488		330	438		478	486		430	334
526	386		278	536		330	538		430	334
378	384		430	486		430	284		378	434
434	282		326	486		334	384		430	436
430	588		426	384		430	488		530	432
430	436		378	334		478	436		526	436
478	588		430	434		478	486		478	488
478	486		430	382		382	384		482	438
526	486		474	434		578	386		426	386
382	334		330	488		430	486		382	488
382	486		378	332		326	436		478	438
530	538		382	536		430	484		430	384
282	536		430	384		478	488		426	486
378	436		426	384		426	536		482	336
478	384		482	384		426	332		382	538
478	282		430	434		378	434		382	332
430	538		474	384		430	488		526	336
330	436		426	436		430	484		382	332
430	538		378	488		530	538		434	384
478	486		482	486		378	334		374	386
478	384		526	384		278	436		382	384
330	386		430	536		478	384		474	436
430	436		378	438		478	536		434	336
430	434		478	434		330	488		530	384
574	384		478	334		378	488		430	434
430	386		430	436		478	384		278	538
382	384		478	334		426	332		526	438
478	282		482	436		382	336		382	488
530	486		382	436		478	332		430	334

Table K.1: Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
378	432		430	486		426	386		382	486
430	432		482	488		478	334		330	538
430	384		330	334		426	334		382	436
430	436		478	436		478	486		378	538
430	384		482	282		434	536		382	386
530	386		430	384		430	282		430	386
326	434		426	384		330	334		426	386
378	386		378	436		430	486		478	488
526	386		478	334		382	436		574	382
478	538		426	384		482	386		430	332
422	386		426	382		330	434		378	384
378	334		326	538		382	384		382	436
330	384		478	484		326	436		426	488
378	384		530	382		434	488		330	436
430	384		426	434		478	382		430	380
478	332		426	334		474	386		474	386
378	384		478	436		430	334		482	486
474	486		434	384		378	382		434	384
578	332		374	334		430	336		478	486
530	384		482	484		526	436		478	486
482	334		430	384		330	336		478	588
378	388		426	382		378	538		482	488
386	384		330	434		430	386		382	384
482	386		478	334		278	386		382	334
434	334		426	384		382	434		578	386
378	384		430	336		430	438		478	282
526	486		382	384		526	334		426	436
530	536		474	438		474	284		330	486
378	436		426	434		482	434		478	434
382	386		478	434		382	438		430	384
278	436		378	436		430	384		474	484
326	538		430	536		378	386		478	438
430	386		426	384		382	488		422	384
426	386		430	436		326	384		430	434
478	434		530	334		326	334		426	536
382	434		426	384		430	484		478	436
374	436		426	434		330	436		530	488
430	486		530	588		430	384		430	384
478	436		374	536		478	434		382	434
430	386		378	488		478	384		482	486
430	382		482	436		426	434		426	484
430	384		430	384		430	436		430	284
378	488		326	384		426	386		578	536
530	486		382	434		434	382		478	484
330	384		382	436		382	384		530	382
430	438		430	384		430	386		378	436
526	486		478	488		482	386		378	384
378	536		474	486		378	436		430	386
530	536		374	334		526	536		478	436
426	438		378	436		382	538		434	488
430	488		478	332		530	434		374	436
426	438		330	488		430	486		478	386
330	488		478	382		430	436		430	436
430	434		430	484		430	382		626	438
426	536		426	332		430	436		482	336
426	332		474	488		430	334		430	386
326	386		278	336		382	488		430	436
378	436		530	332		378	538		378	436
478	334		378	538		382	332		526	434
382	382		430	488		378	382		434	334

Table K.1: Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
282	486		434	436		430	386		382	384
434	388		474	386		378	334		478	638
482	334		426	488		430	486		430	436
378	384		378	436		482	386		482	336
430	486		430	486		430	284		478	486
382	488		426	282		430	436		426	486
282	384		334	486		378	386		478	384
382	486		326	486		526	436		526	484
378	282		378	434		482	436		478	434
482	434		526	382		426	334		482	486
474	434		378	386		526	386		474	384
430	486		382	486		430	386		378	436
382	488		430	436		382	332		474	436
382	384		382	382		382	436		482	486
330	386		478	386		378	382		526	282
478	486		426	536		426	332		482	334
434	384		378	384		382	488		430	434
330	384		474	384		382	384		374	336
382	436		530	488		474	284		478	486
578	484		530	534		478	436		426	334
478	334		430	282		430	486		482	488
330	384		378	384		330	436		430	436
526	486		382	436		478	436		382	334
530	538		430	384		426	436		530	386
382	334		430	384		474	436		430	384
478	384		378	386		578	384		426	334
430	334		482	336		522	486		430	486
482	336		422	484		430	384		430	434
430	486		478	588		482	332		426	384
426	384		426	436		422	336		526	536
430	386		482	438		430	536		386	334
430	282		330	386		526	434		430	486
574	436		530	486		330	486		378	438
526	332		578	384		530	538		426	282
478	282		430	384		382	332		430	434
430	386		430	332		482	436		378	486
430	386		330	438		374	334		378	488
478	488		434	438		382	334		326	436
474	434		482	436		478	588		426	434
482	384		478	436		378	484		430	336
426	436		430	436		474	484		478	332
382	282		526	586		530	434		426	486
430	384		430	488		430	384		430	488
378	334		430	386		530	334		478	334
474	434		426	484		378	486		478	434
482	386		478	334		574	488		430	384
430	536		478	486		430	434		426	436
378	486		382	384		478	436		478	386
478	386		434	436		430	336		434	486
282	436		530	588		478	438		334	538
474	434		478	384		430	486		430	334
474	332		378	486		378	384		526	386
430	334		330	436		474	384		482	436
430	434		382	434		478	332		434	386
530	438		382	436		326	334		482	536
430	536		478	436		482	282		482	282
382	436		326	434		330	432		278	384
378	334		482	384		478	282		478	334
474	332		378	384		374	386		478	484
430	386		526	488		478	334		430	486

Table K.1: Simulation Results for the Hybrid Tradeoff Equal–SKU Split Example *(continued)*.

NVA	VA		NVA	VA		NVA	VA		NVA	VA
330	432		330	332		478	486		430	436
326	332		430	384		282	486		482	538
382	334		426	538		430	436		474	434
474	434		430	334		330	336		430	488
478	538		378	536		430	436		482	434
330	438		530	332		382	484		530	334
378	386		526	382		326	488		478	436
378	386		382	436		378	384		326	538
474	334		378	334		478	284		526	386
430	484		430	488		426	384		530	384
282	536		378	334		378	434		530	488
430	436		430	488		426	436		482	486
382	486		482	384		278	384		426	586
482	386		430	434		382	384		334	486
478	486		430	386		330	386		426	384
482	434		530	332		482	536		482	382
474	438		478	334		330	436		378	434
378	436		526	486		430	384		326	386
382	436		478	486		482	436		474	386
482	384		526	388		478	334		430	484
326	334		430	434		478	386		426	436
482	538		382	386		426	384		430	486
478	384		382	486		430	386		526	438
330	438		430	384		478	334		382	384
478	536		478	484		578	382		378	486
378	334		482	436		426	436		478	386
378	484		430	384		478	534		478	386
330	434		430	382		530	384		478	538
478	486		378	434		430	434		478	384
378	436		374	384		330	282		478	434
478	436		426	384		426	334		478	436
378	436		378	334		478	384		430	436
474	434		478	382		378	334		430	434
378	386		482	434		478	282		578	386
382	384		478	436		330	588		478	434
430	538		482	488		230	438		378	436
482	436		474	436		378	486		526	486
430	384		382	334		478	536		482	334
430	232		574	436		578	488		382	334
430	488		382	388		482	438		482	488
526	336		482	436		478	388		426	436
478	336		478	486		430	488		526	434
578	486		334	332		378	334		430	538
334	488		430	386		434	386		378	538
378	486		482	384		382	232		430	432
426	488		430	388		430	386		526	434
430	386		382	486		378	386		530	386
378	436		482	434		326	536		430	436
430	384		430	538		526	486		430	486
382	384		326	386		426	434		374	384
382	336		378	386		478	436		330	334
434	436		382	484		526	438		426	436

Appendix L

All Hybrid Example Data – Combined

In this appendix we present the combined data for the all hybrid example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Avg. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table L.1: All Hybrid Example Data – Combined.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
1	21	21.1	20.0	7.0	19.0	32.0	36.0	50.0	4.0	1.0	HY
2	21	6.9	2.0	11.0	8.0	11.0	8.0	3.0	8.0	4.0	HY
3	21	27.3	32.0	40.0	3.0	42.0	0.0	29.0	41.0	31.0	HY
4	21	5.6	5.0	3.0	7.0	8.0	6.0	6.0	7.0	3.0	HY
5	21	20.0	17.0	19.0	23.0	21.0	18.0	9.0	29.0	24.0	HY
6	21	4.6	5.0	4.0	7.0	5.0	3.0	2.0	6.0	5.0	HY
7	21	16.8	25.0	28.0	29.0	8.0	3.0	2.0	25.0	14.0	HY
8	21	8.0	8.0	4.0	12.0	1.0	7.0	10.0	11.0	11.0	HY
9	21	15.5	2.0	7.0	29.0	18.0	10.0	6.0	26.0	26.0	HY
10	21	4.1	4.0	7.0	4.0	3.0	3.0	2.0	6.0	4.0	HY
11	21	2.4	0.0	0.0	4.0	4.0	1.0	4.0	3.0	3.0	HY
12	22	4.9	5.0	8.0	5.0	10.0	2.0	2.0	5.0	2.0	HY
13	22	20.0	14.0	8.0	19.0	23.0	11.0	31.0	25.0	29.0	HY
14	22	7.0	13.0	10.0	13.0	2.0	4.0	8.0	5.0	1.0	HY
15	22	5.3	2.0	9.0	4.0	4.0	10.0	7.0	0.0	6.0	HY
16	22	29.8	34.0	45.0	40.0	17.0	16.0	34.0	40.0	12.0	HY
17	22	17.8	4.0	26.0	32.0	1.0	26.0	2.0	26.0	25.0	HY
18	22	3.9	5.0	6.0	6.0	4.0	2.0	3.0	4.0	1.0	HY
19	22	34.8	47.0	36.0	34.0	44.0	29.0	20.0	47.0	21.0	HY
20	22	4.4	0.0	1.0	7.0	5.0	8.0	8.0	4.0	2.0	HY

Table L.1: All Hybrid Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
21	22	10.0	14.0	12.0	6.0	6.0	11.0	4.0	7.0	20.0	HY
22	22	29.8	9.0	11.0	44.0	32.0	41.0	28.0	35.0	38.0	HY
23	22	9.9	15.0	2.0	11.0	5.0	14.0	1.0	23.0	8.0	HY
24	22	26.3	45.0	17.0	51.0	2.0	32.0	45.0	16.0	2.0	HY
25	22	16.0	15.0	20.0	0.0	9.0	17.0	26.0	26.0	15.0	HY
26	23	12.5	15.0	3.0	20.0	6.0	10.0	12.0	22.0	12.0	HY
27	23	31.9	51.0	15.0	37.0	44.0	14.0	45.0	30.0	19.0	HY
28	23	4.6	6.0	1.0	3.0	4.0	8.0	6.0	2.0	7.0	HY
29	23	12.5	14.0	17.0	6.0	17.0	17.0	15.0	12.0	2.0	HY
30	23	2.8	3.0	1.0	3.0	3.0	5.0	5.0	2.0	0.0	HY
31	23	28.1	20.0	21.0	31.0	0.0	25.0	43.0	50.0	35.0	HY
32	23	31.0	48.0	54.0	42.0	6.0	21.0	14.0	26.0	37.0	HY
33	23	21.9	6.0	17.0	8.0	4.0	1.0	47.0	49.0	43.0	HY
34	23	3.3	5.0	2.0	5.0	1.0	3.0	2.0	4.0	4.0	HY
35	23	9.8	21.0	4.0	6.0	12.0	4.0	2.0	18.0	11.0	HY
36	23	2.8	5.0	4.0	4.0	2.0	1.0	1.0	3.0	2.0	HY
37	23	13.1	18.0	2.0	6.0	2.0	6.0	48.0	6.0	17.0	HY
38	23	20.6	39.0	5.0	1.0	5.0	33.0	29.0	44.0	9.0	HY
39	23	27.5	33.0	0.0	16.0	47.0	26.0	27.0	19.0	52.0	HY
40	24	3.0	4.0	4.0	5.0	1.0	2.0	1.0	4.0	3.0	HY
41	24	26.0	35.0	32.0	32.0	22.0	15.0	30.0	26.0	16.0	HY
42	24	22.0	35.0	27.0	26.0	0.0	40.0	30.0	16.0	2.0	HY
43	24	15.3	19.0	38.0	15.0	8.0	3.0	18.0	4.0	17.0	HY
44	24	38.0	25.0	47.0	41.0	9.0	51.0	58.0	19.0	54.0	HY
45	24	3.4	1.0	2.0	3.0	6.0	3.0	3.0	3.0	6.0	HY
46	24	26.3	27.0	14.0	32.0	12.0	36.0	24.0	30.0	35.0	HY
47	24	18.0	25.0	7.0	14.0	28.0	26.0	15.0	21.0	8.0	HY
48	24	7.5	6.0	12.0	4.0	5.0	5.0	9.0	10.0	9.0	HY
49	24	6.6	11.0	11.0	9.0	2.0	10.0	3.0	5.0	2.0	HY
50	24	17.6	20.0	16.0	23.0	10.0	12.0	16.0	16.0	28.0	HY
51	24	9.9	1.0	18.0	13.0	16.0	9.0	10.0	7.0	5.0	HY
52	25	2.9	1.0	2.0	6.0	3.0	2.0	5.0	0.0	4.0	HY
53	25	26.9	32.0	39.0	39.0	0.0	36.0	31.0	30.0	8.0	HY
54	25	25.1	32.0	31.0	17.0	30.0	1.0	33.0	23.0	34.0	HY
55	25	26.5	17.0	35.0	47.0	52.0	22.0	20.0	7.0	12.0	HY
56	25	28.4	44.0	32.0	34.0	20.0	29.0	22.0	17.0	29.0	HY
57	25	19.5	28.0	49.0	17.0	3.0	18.0	14.0	15.0	12.0	HY
58	25	31.4	54.0	18.0	15.0	57.0	43.0	15.0	2.0	47.0	HY
59	25	10.3	5.0	7.0	7.0	27.0	4.0	23.0	7.0	2.0	HY
60	25	12.0	12.0	3.0	1.0	30.0	13.0	7.0	13.0	17.0	HY
61	25	3.9	1.0	11.0	1.0	3.0	0.0	4.0	9.0	2.0	HY
62	25	22.8	8.0	7.0	49.0	14.0	27.0	13.0	48.0	16.0	HY
63	25	21.1	20.0	9.0	40.0	15.0	17.0	35.0	16.0	17.0	HY
64	26	6.1	4.0	3.0	5.0	11.0	4.0	10.0	9.0	3.0	HY
65	26	11.3	6.0	9.0	35.0	14.0	18.0	5.0	2.0	1.0	HY
66	26	17.3	15.0	24.0	17.0	22.0	20.0	3.0	11.0	26.0	HY
67	26	12.4	4.0	20.0	13.0	14.0	5.0	9.0	19.0	15.0	HY
68	26	16.6	10.0	22.0	15.0	27.0	8.0	15.0	21.0	15.0	HY
69	26	9.3	0.0	3.0	12.0	15.0	14.0	9.0	9.0	12.0	HY
70	26	39.9	35.0	49.0	61.0	1.0	60.0	63.0	2.0	48.0	HY
71	26	30.4	25.0	50.0	34.0	25.0	18.0	4.0	40.0	47.0	HY
72	26	24.5	11.0	9.0	25.0	20.0	32.0	5.0	45.0	49.0	HY
73	26	12.4	13.0	16.0	5.0	16.0	11.0	12.0	17.0	9.0	HY
74	27	36.6	43.0	12.0	32.0	55.0	47.0	46.0	44.0	14.0	HY
75	27	8.1	9.0	1.0	9.0	8.0	10.0	14.0	1.0	13.0	HY
76	27	21.6	23.0	12.0	29.0	8.0	1.0	4.0	70.0	26.0	HY
77	27	34.4	48.0	50.0	5.0	38.0	44.0	11.0	33.0	46.0	HY
78	27	23.5	27.0	29.0	4.0	26.0	27.0	12.0	21.0	42.0	HY
79	27	24.4	30.0	17.0	1.0	27.0	8.0	43.0	26.0	43.0	HY
80	27	25.5	26.0	34.0	35.0	51.0	18.0	1.0	38.0	1.0	HY

Table L.1: All Hybrid Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
81	27	7.3	12.0	2.0	15.0	5.0	4.0	6.0	10.0	4.0	HY
82	27	33.9	33.0	38.0	42.0	40.0	18.0	40.0	39.0	21.0	HY
83	28	41.5	62.0	47.0	58.0	31.0	52.0	41.0	1.0	40.0	HY
84	28	24.4	38.0	2.0	35.0	23.0	17.0	20.0	36.0	24.0	HY
85	28	11.6	5.0	1.0	24.0	12.0	1.0	30.0	4.0	16.0	HY
86	28	26.1	7.0	29.0	16.0	52.0	30.0	40.0	12.0	23.0	HY
87	28	5.9	0.0	5.0	9.0	10.0	4.0	8.0	11.0	0.0	HY
88	28	14.9	18.0	8.0	32.0	1.0	3.0	8.0	7.0	42.0	HY
89	28	2.6	8.0	4.0	0.0	1.0	1.0	1.0	4.0	2.0	HY
90	28	22.9	34.0	26.0	10.0	4.0	36.0	42.0	19.0	12.0	HY
91	28	32.1	33.0	4.0	45.0	48.0	58.0	2.0	35.0	32.0	HY
92	29	34.8	26.0	40.0	44.0	57.0	25.0	12.0	20.0	54.0	HY
93	29	31.0	10.0	39.0	38.0	43.0	4.0	21.0	48.0	45.0	HY
94	29	14.9	9.0	12.0	27.0	12.0	2.0	17.0	23.0	17.0	HY
95	29	31.1	39.0	21.0	7.0	8.0	59.0	60.0	27.0	28.0	HY
96	29	33.3	29.0	47.0	55.0	17.0	52.0	39.0	5.0	22.0	HY
97	29	33.3	28.0	14.0	6.0	30.0	44.0	51.0	56.0	37.0	HY
98	29	9.9	16.0	14.0	13.0	6.0	0.0	18.0	12.0	0.0	HY
99	29	15.4	14.0	22.0	1.0	27.0	7.0	14.0	8.0	30.0	HY
100	29	40.0	71.0	12.0	60.0	24.0	40.0	35.0	55.0	23.0	HY
101	30	21.3	28.0	18.0	30.0	2.0	39.0	39.0	4.0	10.0	HY
102	30	22.4	3.0	17.0	31.0	32.0	15.0	23.0	22.0	36.0	HY
103	30	20.0	36.0	19.0	2.0	22.0	37.0	0.0	28.0	16.0	HY
104	30	22.5	23.0	27.0	3.0	20.0	33.0	19.0	31.0	24.0	HY
105	30	15.6	17.0	19.0	20.0	6.0	25.0	12.0	11.0	15.0	HY
106	30	6.6	10.0	4.0	8.0	6.0	5.0	5.0	3.0	12.0	HY
107	30	4.3	11.0	3.0	4.0	6.0	3.0	2.0	0.0	5.0	HY
108	31	20.8	16.0	17.0	20.0	22.0	14.0	15.0	45.0	17.0	HY
109	31	2.9	5.0	3.0	4.0	3.0	1.0	5.0	0.0	2.0	HY
110	31	34.5	14.0	59.0	54.0	8.0	46.0	46.0	26.0	23.0	HY
111	31	22.1	16.0	14.0	7.0	42.0	11.0	29.0	19.0	39.0	HY
112	31	33.1	29.0	18.0	1.0	18.0	62.0	46.0	36.0	55.0	HY
113	31	29.4	29.0	20.0	32.0	47.0	36.0	31.0	31.0	9.0	HY
114	31	6.9	8.0	1.0	2.0	15.0	5.0	4.0	6.0	14.0	HY
115	32	2.1	2.0	1.0	4.0	3.0	1.0	3.0	1.0	2.0	HY
116	32	19.4	23.0	15.0	29.0	9.0	28.0	7.0	21.0	23.0	HY
117	32	30.8	23.0	38.0	6.0	46.0	51.0	7.0	73.0	2.0	HY
118	32	30.0	0.0	29.0	15.0	15.0	65.0	56.0	21.0	39.0	HY
119	32	10.5	15.0	3.0	23.0	1.0	12.0	5.0	8.0	17.0	HY
120	32	31.3	21.0	21.0	40.0	19.0	7.0	41.0	51.0	50.0	HY
121	32	19.4	6.0	10.0	31.0	29.0	30.0	12.0	11.0	26.0	HY
122	33	26.0	62.0	1.0	46.0	6.0	16.0	55.0	9.0	13.0	HY
123	33	26.3	36.0	36.0	2.0	11.0	20.0	77.0	9.0	19.0	HY
124	33	18.5	12.0	3.0	32.0	10.0	8.0	40.0	23.0	20.0	HY
125	33	27.0	26.0	46.0	41.0	38.0	26.0	23.0	10.0	6.0	HY
126	33	28.1	49.0	44.0	45.0	21.0	33.0	10.0	20.0	3.0	HY
127	33	4.4	3.0	4.0	10.0	1.0	4.0	1.0	9.0	3.0	HY
128	34	33.6	19.0	23.0	43.0	42.0	34.0	44.0	1.0	63.0	HY
129	34	14.1	4.0	22.0	7.0	10.0	27.0	15.0	17.0	11.0	HY
130	34	21.6	25.0	39.0	36.0	19.0	4.0	12.0	17.0	21.0	HY
131	34	41.6	6.0	60.0	41.0	80.0	48.0	4.0	71.0	23.0	HY
132	34	19.4	9.0	26.0	23.0	19.0	14.0	28.0	21.0	15.0	HY
133	34	3.9	2.0	3.0	9.0	8.0	3.0	3.0	3.0	0.0	HY
134	35	8.4	0.0	8.0	9.0	12.0	5.0	12.0	9.0	12.0	HY
135	35	42.0	37.0	82.0	44.0	21.0	12.0	71.0	61.0	8.0	HY
136	35	25.1	12.0	47.0	42.0	46.0	1.0	18.0	35.0	0.0	HY
137	35	48.5	74.0	48.0	8.0	64.0	59.0	46.0	10.0	79.0	HY
138	35	19.9	5.0	17.0	36.0	26.0	18.0	9.0	35.0	13.0	HY
139	36	28.4	33.0	13.0	26.0	34.0	20.0	16.0	35.0	50.0	HY
140	36	4.9	2.0	7.0	7.0	1.0	9.0	7.0	0.0	6.0	HY

Table L.1: All Hybrid Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
141	36	2.9	4.0	3.0	5.0	0.0	3.0	3.0	3.0	2.0	HY
142	36	45.6	52.0	39.0	36.0	40.0	34.0	56.0	83.0	25.0	HY
143	36	7.3	5.0	11.0	6.0	11.0	11.0	6.0	4.0	4.0	HY
144	37	44.4	24.0	51.0	89.0	23.0	82.0	28.0	14.0	44.0	HY
145	37	8.1	0.0	6.0	22.0	4.0	0.0	11.0	2.0	20.0	HY
146	37	17.4	1.0	9.0	3.0	45.0	38.0	31.0	5.0	7.0	HY
147	37	14.4	13.0	21.0	18.0	5.0	7.0	11.0	25.0	15.0	HY
148	37	35.5	59.0	8.0	25.0	64.0	68.0	3.0	12.0	45.0	HY
149	38	38.8	12.0	53.0	42.0	49.0	42.0	62.0	24.0	26.0	HY
150	38	14.3	7.0	27.0	25.0	11.0	11.0	18.0	6.0	9.0	HY
151	38	2.3	1.0	2.0	4.0	1.0	1.0	1.0	4.0	4.0	HY
152	38	21.6	16.0	10.0	10.0	38.0	36.0	38.0	3.0	22.0	HY
153	38	15.4	34.0	18.0	10.0	4.0	6.0	7.0	9.0	35.0	HY
154	39	2.8	6.0	1.0	3.0	1.0	2.0	0.0	4.0	5.0	HY
155	39	10.9	19.0	1.0	1.0	19.0	12.0	4.0	19.0	12.0	HY
156	39	36.5	36.0	26.0	53.0	63.0	19.0	63.0	7.0	25.0	HY
157	39	33.4	40.0	20.0	44.0	37.0	30.0	35.0	43.0	18.0	HY
158	40	16.3	13.0	17.0	9.0	8.0	28.0	23.0	26.0	6.0	HY
159	40	4.3	3.0	7.0	7.0	1.0	8.0	5.0	3.0	0.0	HY
160	40	32.0	32.0	76.0	23.0	26.0	9.0	49.0	26.0	15.0	HY
161	40	53.6	26.0	84.0	0.0	76.0	9.0	64.0	84.0	86.0	HY
162	41	2.8	3.0	2.0	6.0	3.0	2.0	1.0	4.0	1.0	HY
163	41	29.9	8.0	44.0	41.0	27.0	15.0	33.0	31.0	40.0	HY
164	41	7.3	8.0	3.0	15.0	15.0	6.0	2.0	8.0	1.0	HY
165	41	7.9	3.0	15.0	1.0	8.0	6.0	9.0	17.0	4.0	HY
166	42	20.0	16.0	13.0	19.0	17.0	32.0	26.0	7.0	30.0	HY
167	42	14.0	6.0	13.0	7.0	13.0	19.0	12.0	20.0	22.0	HY
168	42	5.0	11.0	1.0	7.0	2.0	10.0	4.0	2.0	3.0	HY
169	42	9.8	4.0	21.0	1.0	14.0	18.0	1.0	10.0	9.0	HY
170	43	8.4	3.0	7.0	14.0	10.0	1.0	3.0	6.0	23.0	HY
171	43	2.5	4.0	3.0	3.0	2.0	0.0	4.0	2.0	2.0	HY
172	43	13.3	14.0	11.0	22.0	11.0	5.0	18.0	8.0	17.0	HY
173	44	5.5	3.0	9.0	1.0	8.0	3.0	4.0	8.0	8.0	HY
174	44	27.3	31.0	44.0	21.0	19.0	42.0	44.0	5.0	12.0	HY
175	44	36.5	6.0	13.0	55.0	30.0	1.0	84.0	28.0	75.0	HY
176	44	55.0	78.0	69.0	10.0	19.0	35.0	77.0	76.0	76.0	HY
177	45	21.4	10.0	5.0	1.0	26.0	27.0	37.0	27.0	38.0	HY
178	45	42.0	51.0	38.0	60.0	48.0	49.0	28.0	10.0	52.0	HY
179	45	26.6	51.0	46.0	1.0	48.0	12.0	8.0	13.0	34.0	HY
180	46	17.8	19.0	32.0	33.0	4.0	10.0	1.0	31.0	12.0	HY
181	46	3.8	4.0	4.0	5.0	1.0	2.0	3.0	6.0	5.0	HY
182	46	37.9	14.0	41.0	27.0	37.0	37.0	59.0	45.0	43.0	HY
183	47	2.5	1.0	3.0	2.0	1.0	4.0	2.0	5.0	2.0	HY
184	47	71.0	90.0	62.0	89.0	21.0	32.0	84.0	83.0	107.0	HY
185	47	20.5	4.0	1.0	18.0	21.0	32.0	34.0	30.0	24.0	HY
186	48	64.1	71.0	23.0	63.0	33.0	84.0	75.0	82.0	82.0	HY
187	48	51.8	58.0	95.0	14.0	86.0	57.0	1.0	52.0	51.0	HY
188	49	28.0	15.0	42.0	63.0	14.0	28.0	36.0	23.0	3.0	HY
189	49	54.6	67.0	49.0	17.0	104.0	63.0	9.0	106.0	22.0	HY
190	49	61.5	72.0	75.0	64.0	21.0	76.0	73.0	56.0	55.0	HY
191	50	64.4	116.0	27.0	64.0	55.0	32.0	21.0	100.0	100.0	HY
192	50	35.1	74.0	4.0	40.0	5.0	72.0	29.0	48.0	9.0	HY
193	50	22.9	1.0	46.0	37.0	40.0	8.0	16.0	26.0	9.0	HY
194	51	28.3	50.0	33.0	27.0	21.0	16.0	27.0	34.0	18.0	HY
195	51	2.9	2.0	3.0	0.0	2.0	4.0	5.0	4.0	3.0	HY
196	52	50.6	80.0	48.0	86.0	29.0	20.0	14.0	36.0	92.0	HY
197	52	38.4	15.0	45.0	24.0	37.0	26.0	58.0	57.0	45.0	HY
198	53	78.1	80.0	76.0	94.0	38.0	105.0	32.0	97.0	103.0	HY
199	53	30.6	8.0	18.0	21.0	29.0	6.0	35.0	75.0	53.0	HY
200	53	46.0	11.0	82.0	36.0	79.0	8.0	8.0	70.0	74.0	HY

Table L.1: All Hybrid Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
201	54	34.0	61.0	16.0	50.0	17.0	20.0	54.0	29.0	25.0	HY
202	54	20.6	16.0	38.0	21.0	28.0	35.0	4.0	21.0	2.0	HY
203	55	38.1	7.0	21.0	70.0	64.0	4.0	19.0	72.0	48.0	HY
204	55	88.4	109.0	82.0	75.0	58.0	100.0	101.0	114.0	68.0	HY
205	56	12.4	15.0	3.0	17.0	2.0	31.0	16.0	8.0	7.0	HY
206	56	80.8	18.0	52.0	118.0	146.0	82.0	66.0	127.0	37.0	HY
207	57	48.1	42.0	34.0	51.0	64.0	73.0	37.0	42.0	42.0	HY
208	57	76.9	20.0	129.0	95.0	36.0	113.0	85.0	12.0	125.0	HY
209	58	73.1	68.0	81.0	128.0	36.0	9.0	127.0	101.0	35.0	HY
210	59	33.1	54.0	44.0	24.0	30.0	8.0	43.0	59.0	3.0	HY
211	59	28.1	38.0	16.0	32.0	9.0	33.0	16.0	34.0	47.0	HY
212	60	49.1	66.0	60.0	31.0	61.0	32.0	66.0	12.0	65.0	HY
213	60	28.6	56.0	40.0	8.0	41.0	10.0	10.0	30.0	34.0	HY
214	61	67.4	120.0	118.0	94.0	28.0	93.0	13.0	63.0	10.0	HY
215	61	4.0	3.0	1.0	5.0	2.0	5.0	6.0	4.0	6.0	HY
216	62	64.5	70.0	107.0	13.0	1.0	132.0	93.0	87.0	13.0	HY
217	63	67.5	80.0	39.0	46.0	61.0	93.0	92.0	48.0	81.0	HY
218	63	72.6	86.0	15.0	55.0	97.0	93.0	84.0	97.0	54.0	HY
219	64	3.3	0.0	4.0	3.0	2.0	2.0	5.0	3.0	7.0	HY
220	65	43.5	63.0	26.0	36.0	31.0	49.0	58.0	47.0	38.0	HY
221	65	30.3	16.0	30.0	34.0	65.0	35.0	40.0	1.0	21.0	HY
222	66	32.0	34.0	50.0	41.0	4.0	45.0	2.0	38.0	42.0	HY
223	67	27.5	6.0	13.0	44.0	46.0	17.0	17.0	39.0	38.0	HY
224	68	14.6	15.0	11.0	22.0	4.0	16.0	25.0	11.0	13.0	HY
225	68	21.5	36.0	29.0	25.0	15.0	4.0	8.0	24.0	31.0	HY
226	69	91.9	169.0	51.0	90.0	112.0	87.0	38.0	56.0	132.0	HY
227	70	48.0	27.0	59.0	52.0	28.0	53.0	73.0	32.0	60.0	HY
228	71	27.8	25.0	18.0	33.0	6.0	13.0	53.0	31.0	43.0	HY
229	72	58.6	99.0	14.0	32.0	31.0	53.0	112.0	100.0	28.0	HY
230	73	74.6	65.0	147.0	66.0	119.0	78.0	17.0	78.0	27.0	HY
231	73	44.9	72.0	17.0	68.0	17.0	27.0	47.0	81.0	30.0	HY
232	74	100.0	73.0	99.0	192.0	32.0	98.0	176.0	70.0	60.0	HY
233	75	25.6	27.0	37.0	18.0	22.0	41.0	29.0	23.0	8.0	HY
234	76	69.6	132.0	28.0	89.0	91.0	84.0	81.0	28.0	24.0	HY
235	77	71.9	6.0	19.0	83.0	59.0	124.0	118.0	86.0	80.0	HY
236	78	51.9	82.0	70.0	77.0	75.0	41.0	37.0	27.0	6.0	HY
237	79	32.9	34.0	35.0	48.0	35.0	27.0	31.0	28.0	25.0	HY
238	80	6.0	6.0	2.0	6.0	5.0	11.0	2.0	7.0	9.0	HY
239	82	98.0	64.0	90.0	83.0	160.0	115.0	42.0	141.0	89.0	HY
240	83	39.3	62.0	54.0	44.0	12.0	48.0	81.0	3.0	10.0	HY
241	84	51.1	85.0	57.0	39.0	103.0	68.0	4.0	50.0	3.0	HY
242	85	27.6	41.0	25.0	46.0	9.0	28.0	37.0	23.0	12.0	HY
243	86	30.6	35.0	1.0	59.0	24.0	11.0	30.0	44.0	41.0	HY
244	88	153.1	198.0	117.0	212.0	171.0	216.0	76.0	169.0	66.0	HY
245	89	104.8	77.0	140.0	119.0	113.0	99.0	71.0	87.0	132.0	HY
246	91	2.4	0.0	0.0	2.0	3.0	4.0	2.0	5.0	3.0	HY
247	92	56.9	46.0	72.0	17.0	81.0	66.0	73.0	82.0	18.0	HY
248	94	51.0	85.0	97.0	53.0	7.0	58.0	10.0	69.0	29.0	HY
249	95	32.1	34.0	3.0	43.0	21.0	32.0	14.0	64.0	46.0	HY
250	97	126.5	150.0	25.0	201.0	171.0	130.0	31.0	151.0	153.0	HY
251	98	85.4	1.0	132.0	67.0	110.0	31.0	129.0	77.0	136.0	HY
252	100	63.6	139.0	46.0	13.0	28.0	117.0	51.0	4.0	111.0	HY
253	102	133.0	129.0	44.0	212.0	97.0	170.0	79.0	119.0	214.0	HY
254	104	55.3	28.0	6.0	82.0	22.0	78.0	67.0	81.0	78.0	HY
255	106	11.0	19.0	2.0	3.0	12.0	7.0	15.0	18.0	12.0	HY
256	108	130.6	116.0	177.0	140.0	156.0	181.0	95.0	66.0	114.0	HY
257	110	119.4	221.0	36.0	39.0	141.0	212.0	96.0	101.0	109.0	HY
258	112	136.5	168.0	96.0	13.0	216.0	256.0	168.0	118.0	57.0	HY
259	114	54.9	52.0	71.0	9.0	57.0	48.0	69.0	57.0	76.0	HY
260	117	37.8	10.0	51.0	38.0	53.0	36.0	46.0	14.0	54.0	HY

Table L.1: All Hybrid Example Data – Combined *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
261	119	83.1	74.0	103.0	74.0	131.0	67.0	31.0	30.0	155.0	HY
262	122	48.9	79.0	41.0	23.0	70.0	49.0	47.0	54.0	28.0	HY
263	125	121.3	231.0	124.0	28.0	86.0	154.0	202.0	47.0	98.0	HY
264	128	58.3	48.0	22.0	44.0	104.0	99.0	41.0	13.0	95.0	HY
265	131	42.5	36.0	43.0	47.0	48.0	59.0	50.0	41.0	16.0	HY
266	134	48.0	28.0	17.0	23.0	71.0	74.0	51.0	29.0	91.0	HY
267	138	131.8	270.0	109.0	70.0	25.0	72.0	5.0	189.0	314.0	HY
268	141	188.4	310.0	337.0	89.0	179.0	50.0	241.0	103.0	198.0	HY
269	145	198.0	202.0	342.0	104.0	39.0	271.0	179.0	162.0	285.0	HY
270	149	4.4	6.0	3.0	4.0	7.0	1.0	3.0	6.0	5.0	HY
271	154	174.4	223.0	315.0	235.0	133.0	55.0	256.0	66.0	112.0	HY
272	158	195.1	0.0	121.0	176.0	269.0	326.0	272.0	53.0	344.0	HY
273	163	49.9	36.0	42.0	70.0	20.0	68.0	74.0	69.0	20.0	HY
274	168	57.3	5.0	52.0	81.0	45.0	68.0	50.0	65.0	92.0	HY
275	174	128.1	140.0	79.0	85.0	131.0	140.0	168.0	100.0	182.0	HY
276	180	212.6	406.0	37.0	86.0	228.0	27.0	376.0	319.0	222.0	HY
277	187	221.1	210.0	256.0	46.0	196.0	225.0	269.0	312.0	255.0	HY
278	194	71.0	123.0	180.0	59.0	26.0	51.0	0.0	68.0	61.0	HY
279	202	17.1	8.0	30.0	13.0	10.0	4.0	26.0	15.0	31.0	HY
280	210	144.6	203.0	197.0	26.0	43.0	140.0	199.0	122.0	227.0	HY
281	219	48.6	27.0	47.0	49.0	103.0	44.0	13.0	81.0	25.0	HY
282	230	255.4	135.0	404.0	368.0	256.0	132.0	32.0	186.0	530.0	HY
283	241	28.1	24.0	67.0	6.0	40.0	13.0	4.0	34.0	37.0	HY
284	253	278.8	374.0	164.0	48.0	313.0	474.0	283.0	99.0	475.0	HY
285	267	139.9	111.0	187.0	76.0	162.0	98.0	191.0	103.0	191.0	HY
286	283	358.8	520.0	287.0	486.0	384.0	416.0	32.0	173.0	572.0	HY
287	301	121.0	150.0	192.0	47.0	180.0	75.0	197.0	0.0	127.0	HY
288	322	117.9	164.0	136.0	33.0	126.0	51.0	177.0	87.0	169.0	HY
289	346	385.1	764.0	346.0	435.0	33.0	506.0	789.0	124.0	84.0	HY
290	374	76.6	78.0	64.0	62.0	77.0	103.0	51.0	65.0	113.0	HY
291	408	189.9	180.0	328.0	267.0	171.0	189.0	176.0	23.0	185.0	HY
292	449	276.4	90.0	157.0	463.0	81.0	439.0	277.0	677.0	27.0	HY
293	500	66.8	128.0	52.0	70.0	2.0	131.0	10.0	87.0	54.0	HY
294	566	349.8	533.0	1.0	30.0	400.0	461.0	791.0	462.0	120.0	HY
295	654	716.8	274.0	671.0	1232.0	724.0	910.0	169.0	1099.0	655.0	HY
296	778	410.3	117.0	143.0	264.0	139.0	486.0	738.0	839.0	556.0	HY
297	968	218.0	397.0	450.0	3.0	88.0	1.0	317.0	324.0	164.0	HY
298	1300	717.1	1023.0	25.0	1328.0	1079.0	573.0	135.0	1235.0	339.0	HY
299	2060	2122.3	2209.0	2104.0	1059.0	1158.0	2024.0	2955.0	2511.0	2958.0	HY
300	20365	14071.8	18155.0	15498.0	1092.0	24565.0	8921.0	20914.0	21938.0	1491.0	HY

Appendix M

All Hybrid Example Data – Separate

In this appendix we present the separate data for the all hybrid example. The column labeled "SKU" presents the SKU number. The column labeled "Demand" represents the demand for the given SKU. The column labeled "Avg. Inv." represents the average inventory over an 8-week period for the given SKU. The columns labeled "Week 1" through "Week 8" represent the inventory level at the end of the given week. The column labeled "Dept." represents the department in which the given SKU is located.

Table M.1: All Hybrid Example Data – Separate NVA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
1	21	14.1	13.0	5.0	13.0	21.0	24.0	33.0	3.0	1.0	HY-NVA
2	21	5.1	2.0	8.0	6.0	8.0	6.0	2.0	6.0	3.0	HY-NVA
3	21	18.0	21.0	26.0	2.0	28.0	0.0	19.0	27.0	21.0	HY-NVA
4	21	4.0	4.0	2.0	5.0	6.0	4.0	4.0	5.0	2.0	HY-NVA
5	21	13.4	12.0	13.0	15.0	14.0	12.0	6.0	19.0	16.0	HY-NVA
6	21	3.5	4.0	3.0	5.0	4.0	2.0	2.0	4.0	4.0	HY-NVA
7	21	11.5	17.0	19.0	19.0	6.0	2.0	2.0	17.0	10.0	HY-NVA
8	21	5.8	6.0	3.0	8.0	1.0	5.0	7.0	8.0	8.0	HY-NVA
9	21	10.4	2.0	5.0	19.0	12.0	7.0	4.0	17.0	17.0	HY-NVA
10	21	3.0	3.0	5.0	3.0	2.0	2.0	2.0	4.0	3.0	HY-NVA
11	21	1.8	0.0	0.0	3.0	3.0	1.0	3.0	2.0	2.0	HY-NVA
12	22	3.9	4.0	6.0	4.0	7.0	2.0	2.0	4.0	2.0	HY-NVA
13	22	13.6	10.0	6.0	13.0	15.0	8.0	21.0	17.0	19.0	HY-NVA
14	22	5.1	9.0	7.0	9.0	2.0	3.0	6.0	4.0	1.0	HY-NVA
15	22	3.8	2.0	6.0	3.0	3.0	7.0	5.0	0.0	4.0	HY-NVA
16	22	19.9	23.0	30.0	26.0	12.0	11.0	23.0	26.0	8.0	HY-NVA
17	22	11.9	3.0	17.0	21.0	1.0	17.0	2.0	17.0	17.0	HY-NVA
18	22	2.9	4.0	4.0	4.0	3.0	2.0	2.0	3.0	1.0	HY-NVA
19	22	23.0	31.0	24.0	23.0	29.0	19.0	13.0	31.0	14.0	HY-NVA
20	22	3.4	0.0	1.0	5.0	4.0	6.0	6.0	3.0	2.0	HY-NVA

Table M.1: All Hybrid Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
21	22	6.9	10.0	8.0	4.0	4.0	8.0	3.0	5.0	13.0	HY-NVA
22	22	19.8	6.0	8.0	29.0	21.0	27.0	19.0	23.0	25.0	HY-NVA
23	22	7.0	10.0	2.0	8.0	4.0	10.0	1.0	15.0	6.0	HY-NVA
24	22	17.8	30.0	12.0	34.0	2.0	21.0	30.0	11.0	2.0	HY-NVA
25	22	10.6	10.0	13.0	0.0	6.0	12.0	17.0	17.0	10.0	HY-NVA
26	23	8.4	10.0	2.0	13.0	4.0	7.0	8.0	15.0	8.0	HY-NVA
27	23	21.4	34.0	10.0	25.0	29.0	10.0	30.0	20.0	13.0	HY-NVA
28	23	3.4	4.0	1.0	2.0	3.0	6.0	4.0	2.0	5.0	HY-NVA
29	23	8.8	10.0	12.0	4.0	12.0	12.0	10.0	8.0	2.0	HY-NVA
30	23	2.1	2.0	1.0	2.0	2.0	4.0	4.0	2.0	0.0	HY-NVA
31	23	18.6	13.0	14.0	21.0	0.0	17.0	28.0	33.0	23.0	HY-NVA
32	23	20.8	32.0	36.0	28.0	4.0	14.0	10.0	17.0	25.0	HY-NVA
33	23	14.6	4.0	12.0	6.0	3.0	1.0	31.0	32.0	28.0	HY-NVA
34	23	2.6	4.0	2.0	4.0	1.0	2.0	2.0	3.0	3.0	HY-NVA
35	23	6.8	14.0	3.0	4.0	8.0	3.0	2.0	12.0	8.0	HY-NVA
36	23	2.3	4.0	3.0	3.0	2.0	1.0	1.0	2.0	2.0	HY-NVA
37	23	9.0	12.0	2.0	4.0	2.0	4.0	32.0	4.0	12.0	HY-NVA
38	23	13.9	26.0	4.0	1.0	4.0	22.0	19.0	29.0	6.0	HY-NVA
39	23	18.3	22.0	0.0	11.0	31.0	17.0	18.0	13.0	34.0	HY-NVA
40	24	2.4	3.0	3.0	4.0	1.0	2.0	1.0	3.0	2.0	HY-NVA
41	24	17.3	23.0	21.0	21.0	15.0	10.0	20.0	17.0	11.0	HY-NVA
42	24	14.6	23.0	18.0	17.0	0.0	26.0	20.0	11.0	2.0	HY-NVA
43	24	10.4	13.0	25.0	10.0	6.0	2.0	12.0	3.0	12.0	HY-NVA
44	24	25.3	17.0	31.0	27.0	6.0	34.0	38.0	13.0	36.0	HY-NVA
45	24	2.4	1.0	2.0	2.0	4.0	2.0	2.0	2.0	4.0	HY-NVA
46	24	17.5	18.0	10.0	21.0	8.0	24.0	16.0	20.0	23.0	HY-NVA
47	24	12.3	17.0	5.0	10.0	19.0	17.0	10.0	14.0	6.0	HY-NVA
48	24	5.3	4.0	8.0	3.0	4.0	4.0	6.0	7.0	6.0	HY-NVA
49	24	4.9	8.0	8.0	6.0	2.0	7.0	2.0	4.0	2.0	HY-NVA
50	24	11.9	13.0	11.0	15.0	7.0	8.0	11.0	11.0	19.0	HY-NVA
51	24	6.9	1.0	12.0	9.0	11.0	6.0	7.0	5.0	4.0	HY-NVA
52	25	2.3	1.0	2.0	4.0	2.0	2.0	4.0	0.0	3.0	HY-NVA
53	25	18.0	21.0	26.0	26.0	0.0	24.0	21.0	20.0	6.0	HY-NVA
54	25	16.9	21.0	21.0	12.0	20.0	1.0	22.0	15.0	23.0	HY-NVA
55	25	17.6	12.0	23.0	31.0	34.0	15.0	13.0	5.0	8.0	HY-NVA
56	25	18.9	29.0	21.0	23.0	13.0	19.0	15.0	12.0	19.0	HY-NVA
57	25	13.1	19.0	32.0	12.0	2.0	12.0	10.0	10.0	8.0	HY-NVA
58	25	20.9	36.0	12.0	10.0	38.0	28.0	10.0	2.0	31.0	HY-NVA
59	25	7.1	4.0	5.0	5.0	18.0	3.0	15.0	5.0	2.0	HY-NVA
60	25	8.3	8.0	2.0	1.0	20.0	9.0	5.0	9.0	12.0	HY-NVA
61	25	2.9	1.0	8.0	1.0	2.0	0.0	3.0	6.0	2.0	HY-NVA
62	25	15.4	6.0	5.0	32.0	10.0	18.0	9.0	32.0	11.0	HY-NVA
63	25	14.1	13.0	6.0	26.0	10.0	12.0	23.0	11.0	12.0	HY-NVA
64	26	4.4	3.0	2.0	4.0	8.0	3.0	7.0	6.0	2.0	HY-NVA
65	26	7.8	4.0	6.0	23.0	10.0	12.0	4.0	2.0	1.0	HY-NVA
66	26	11.6	10.0	16.0	12.0	15.0	13.0	2.0	8.0	17.0	HY-NVA
67	26	8.5	3.0	13.0	9.0	10.0	4.0	6.0	13.0	10.0	HY-NVA
68	26	11.3	7.0	15.0	10.0	18.0	6.0	10.0	14.0	10.0	HY-NVA
69	26	6.3	0.0	2.0	8.0	10.0	10.0	6.0	6.0	8.0	HY-NVA
70	26	26.3	23.0	32.0	40.0	1.0	39.0	41.0	2.0	32.0	HY-NVA
71	26	20.3	17.0	33.0	23.0	17.0	12.0	3.0	26.0	31.0	HY-NVA
72	26	16.4	8.0	6.0	17.0	13.0	21.0	4.0	30.0	32.0	HY-NVA
73	26	8.6	9.0	11.0	4.0	11.0	8.0	8.0	12.0	6.0	HY-NVA
74	27	24.1	28.0	8.0	21.0	36.0	31.0	30.0	29.0	10.0	HY-NVA
75	27	5.8	6.0	1.0	6.0	6.0	7.0	10.0	1.0	9.0	HY-NVA
76	27	14.4	15.0	8.0	19.0	6.0	1.0	3.0	46.0	17.0	HY-NVA
77	27	22.9	32.0	33.0	4.0	25.0	29.0	8.0	22.0	30.0	HY-NVA
78	27	15.6	18.0	19.0	3.0	17.0	18.0	8.0	14.0	28.0	HY-NVA
79	27	16.3	20.0	12.0	1.0	18.0	6.0	28.0	17.0	28.0	HY-NVA
80	27	17.0	17.0	23.0	23.0	34.0	12.0	1.0	25.0	1.0	HY-NVA

Table M.1: All Hybrid Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
81	27	5.1	8.0	2.0	10.0	4.0	3.0	4.0	7.0	3.0	HY-NVA
82	27	22.4	22.0	25.0	28.0	26.0	12.0	26.0	26.0	14.0	HY-NVA
83	28	27.4	41.0	31.0	38.0	21.0	34.0	27.0	1.0	26.0	HY-NVA
84	28	16.3	25.0	2.0	23.0	15.0	12.0	13.0	24.0	16.0	HY-NVA
85	28	8.0	4.0	1.0	16.0	8.0	1.0	20.0	3.0	11.0	HY-NVA
86	28	17.3	5.0	19.0	11.0	34.0	20.0	26.0	8.0	15.0	HY-NVA
87	28	4.3	0.0	4.0	6.0	7.0	3.0	6.0	8.0	0.0	HY-NVA
88	28	10.1	12.0	6.0	21.0	1.0	2.0	6.0	5.0	28.0	HY-NVA
89	28	2.1	6.0	3.0	0.0	1.0	1.0	1.0	3.0	2.0	HY-NVA
90	28	15.4	23.0	17.0	7.0	3.0	24.0	28.0	13.0	8.0	HY-NVA
91	28	21.4	22.0	3.0	30.0	32.0	38.0	2.0	23.0	21.0	HY-NVA
92	29	23.0	17.0	26.0	29.0	38.0	17.0	8.0	13.0	36.0	HY-NVA
93	29	20.6	7.0	26.0	25.0	28.0	3.0	14.0	32.0	30.0	HY-NVA
94	29	10.1	6.0	8.0	18.0	8.0	2.0	12.0	15.0	12.0	HY-NVA
95	29	20.8	26.0	14.0	5.0	6.0	39.0	39.0	18.0	19.0	HY-NVA
96	29	22.1	19.0	31.0	36.0	12.0	34.0	26.0	4.0	15.0	HY-NVA
97	29	22.3	19.0	10.0	4.0	20.0	29.0	34.0	37.0	25.0	HY-NVA
98	29	6.8	11.0	10.0	9.0	4.0	0.0	12.0	8.0	0.0	HY-NVA
99	29	10.6	10.0	15.0	1.0	18.0	5.0	10.0	6.0	20.0	HY-NVA
100	29	26.3	47.0	8.0	39.0	16.0	26.0	23.0	36.0	15.0	HY-NVA
101	30	14.4	19.0	12.0	20.0	2.0	26.0	26.0	3.0	7.0	HY-NVA
102	30	15.0	2.0	12.0	21.0	21.0	10.0	15.0	15.0	24.0	HY-NVA
103	30	13.6	24.0	13.0	2.0	15.0	25.0	0.0	19.0	11.0	HY-NVA
104	30	15.0	15.0	18.0	2.0	13.0	22.0	13.0	21.0	16.0	HY-NVA
105	30	10.6	12.0	13.0	13.0	4.0	17.0	8.0	8.0	10.0	HY-NVA
106	30	4.8	7.0	3.0	6.0	4.0	4.0	4.0	2.0	8.0	HY-NVA
107	30	3.1	8.0	2.0	3.0	4.0	2.0	2.0	0.0	4.0	HY-NVA
108	31	14.1	11.0	12.0	13.0	15.0	10.0	10.0	30.0	12.0	HY-NVA
109	31	2.3	4.0	2.0	3.0	2.0	1.0	4.0	0.0	2.0	HY-NVA
110	31	22.9	10.0	39.0	36.0	6.0	30.0	30.0	17.0	15.0	HY-NVA
111	31	15.0	11.0	10.0	5.0	28.0	8.0	19.0	13.0	26.0	HY-NVA
112	31	21.9	19.0	12.0	1.0	12.0	41.0	30.0	24.0	36.0	HY-NVA
113	31	19.5	19.0	13.0	21.0	31.0	24.0	21.0	21.0	6.0	HY-NVA
114	31	5.0	6.0	1.0	2.0	10.0	4.0	3.0	4.0	10.0	HY-NVA
115	32	1.8	2.0	1.0	3.0	2.0	1.0	2.0	1.0	2.0	HY-NVA
116	32	12.9	15.0	10.0	19.0	6.0	19.0	5.0	14.0	15.0	HY-NVA
117	32	20.4	15.0	25.0	4.0	30.0	34.0	5.0	48.0	2.0	HY-NVA
118	32	19.9	0.0	19.0	10.0	10.0	43.0	37.0	14.0	26.0	HY-NVA
119	32	7.3	10.0	2.0	15.0	1.0	8.0	4.0	6.0	12.0	HY-NVA
120	32	20.8	14.0	14.0	26.0	13.0	5.0	27.0	34.0	33.0	HY-NVA
121	32	13.0	4.0	7.0	21.0	19.0	20.0	8.0	8.0	17.0	HY-NVA
122	33	17.3	41.0	1.0	30.0	4.0	11.0	36.0	6.0	9.0	HY-NVA
123	33	17.6	24.0	24.0	2.0	8.0	13.0	51.0	6.0	13.0	HY-NVA
124	33	12.3	8.0	2.0	21.0	7.0	6.0	26.0	15.0	13.0	HY-NVA
125	33	17.8	17.0	30.0	27.0	25.0	17.0	15.0	7.0	4.0	HY-NVA
126	33	18.6	32.0	29.0	30.0	14.0	22.0	7.0	13.0	2.0	HY-NVA
127	33	3.1	2.0	3.0	7.0	1.0	3.0	1.0	6.0	2.0	HY-NVA
128	34	22.3	13.0	15.0	28.0	28.0	23.0	29.0	1.0	41.0	HY-NVA
129	34	9.8	3.0	15.0	5.0	7.0	18.0	10.0	12.0	8.0	HY-NVA
130	34	14.6	17.0	26.0	24.0	13.0	3.0	8.0	12.0	14.0	HY-NVA
131	34	27.4	4.0	39.0	27.0	52.0	32.0	3.0	47.0	15.0	HY-NVA
132	34	13.0	6.0	17.0	15.0	13.0	10.0	19.0	14.0	10.0	HY-NVA
133	34	2.8	2.0	2.0	6.0	6.0	2.0	2.0	2.0	0.0	HY-NVA
134	35	5.8	0.0	6.0	6.0	8.0	4.0	8.0	6.0	8.0	HY-NVA
135	35	27.9	25.0	54.0	29.0	14.0	8.0	47.0	40.0	6.0	HY-NVA
136	35	16.6	8.0	31.0	28.0	30.0	1.0	12.0	23.0	0.0	HY-NVA
137	35	32.1	49.0	32.0	6.0	42.0	39.0	30.0	7.0	52.0	HY-NVA
138	35	13.4	4.0	12.0	24.0	17.0	12.0	6.0	23.0	9.0	HY-NVA
139	36	18.9	22.0	9.0	17.0	23.0	13.0	11.0	23.0	33.0	HY-NVA
140	36	3.5	2.0	5.0	5.0	1.0	6.0	5.0	0.0	4.0	HY-NVA

Table M.1: All Hybrid Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
141	36	2.1	3.0	2.0	4.0	0.0	2.0	2.0	2.0	2.0	HY-NVA
142	36	30.1	34.0	26.0	24.0	26.0	23.0	37.0	54.0	17.0	HY-NVA
143	36	5.3	4.0	8.0	4.0	8.0	8.0	4.0	3.0	3.0	HY-NVA
144	37	29.4	16.0	34.0	58.0	15.0	54.0	19.0	10.0	29.0	HY-NVA
145	37	5.6	0.0	4.0	15.0	3.0	0.0	8.0	2.0	13.0	HY-NVA
146	37	11.8	1.0	6.0	2.0	30.0	25.0	21.0	4.0	5.0	HY-NVA
147	37	9.9	9.0	14.0	12.0	4.0	5.0	8.0	17.0	10.0	HY-NVA
148	37	23.6	39.0	6.0	17.0	42.0	45.0	2.0	8.0	30.0	HY-NVA
149	38	25.6	8.0	35.0	28.0	32.0	28.0	41.0	16.0	17.0	HY-NVA
150	38	9.8	5.0	18.0	17.0	8.0	8.0	12.0	4.0	6.0	HY-NVA
151	38	1.9	1.0	2.0	3.0	1.0	1.0	1.0	3.0	3.0	HY-NVA
152	38	14.5	11.0	7.0	7.0	25.0	24.0	25.0	2.0	15.0	HY-NVA
153	38	10.4	23.0	12.0	7.0	3.0	4.0	5.0	6.0	23.0	HY-NVA
154	39	2.1	4.0	1.0	2.0	1.0	2.0	0.0	3.0	4.0	HY-NVA
155	39	7.5	13.0	1.0	1.0	13.0	8.0	3.0	13.0	8.0	HY-NVA
156	39	24.1	24.0	17.0	35.0	41.0	13.0	41.0	5.0	17.0	HY-NVA
157	39	22.0	26.0	13.0	29.0	25.0	20.0	23.0	28.0	12.0	HY-NVA
158	40	11.0	9.0	12.0	6.0	6.0	19.0	15.0	17.0	4.0	HY-NVA
159	40	3.1	2.0	5.0	5.0	1.0	6.0	4.0	2.0	0.0	HY-NVA
160	40	21.0	21.0	50.0	15.0	17.0	6.0	32.0	17.0	10.0	HY-NVA
161	40	35.1	17.0	55.0	0.0	50.0	6.0	42.0	55.0	56.0	HY-NVA
162	41	2.1	2.0	2.0	4.0	2.0	2.0	1.0	3.0	1.0	HY-NVA
163	41	19.9	6.0	29.0	27.0	18.0	10.0	22.0	21.0	26.0	HY-NVA
164	41	5.1	6.0	2.0	10.0	10.0	4.0	2.0	6.0	1.0	HY-NVA
165	41	5.5	2.0	10.0	1.0	6.0	4.0	6.0	12.0	3.0	HY-NVA
166	42	13.5	11.0	9.0	13.0	12.0	21.0	17.0	5.0	20.0	HY-NVA
167	42	9.5	4.0	9.0	5.0	9.0	13.0	8.0	13.0	15.0	HY-NVA
168	42	3.8	8.0	1.0	5.0	2.0	7.0	3.0	2.0	2.0	HY-NVA
169	42	6.8	3.0	14.0	1.0	10.0	12.0	1.0	7.0	6.0	HY-NVA
170	43	5.8	2.0	5.0	10.0	7.0	1.0	2.0	4.0	15.0	HY-NVA
171	43	2.0	3.0	2.0	2.0	2.0	0.0	3.0	2.0	2.0	HY-NVA
172	43	9.4	10.0	8.0	15.0	8.0	4.0	12.0	6.0	12.0	HY-NVA
173	44	4.0	2.0	6.0	1.0	6.0	2.0	3.0	6.0	6.0	HY-NVA
174	44	18.3	21.0	29.0	14.0	13.0	28.0	29.0	4.0	8.0	HY-NVA
175	44	24.1	4.0	9.0	36.0	20.0	1.0	55.0	19.0	49.0	HY-NVA
176	44	36.3	51.0	45.0	7.0	13.0	23.0	51.0	50.0	50.0	HY-NVA
177	45	14.4	7.0	4.0	1.0	17.0	18.0	25.0	18.0	25.0	HY-NVA
178	45	27.8	34.0	25.0	39.0	32.0	32.0	19.0	7.0	34.0	HY-NVA
179	45	17.9	34.0	30.0	1.0	32.0	8.0	6.0	9.0	23.0	HY-NVA
180	46	12.0	13.0	21.0	22.0	3.0	7.0	1.0	21.0	8.0	HY-NVA
181	46	2.9	3.0	3.0	4.0	1.0	2.0	2.0	4.0	4.0	HY-NVA
182	46	25.3	10.0	27.0	18.0	25.0	25.0	39.0	30.0	28.0	HY-NVA
183	47	2.1	1.0	2.0	2.0	1.0	3.0	2.0	4.0	2.0	HY-NVA
184	47	46.5	59.0	41.0	58.0	14.0	21.0	55.0	54.0	70.0	HY-NVA
185	47	13.8	3.0	1.0	12.0	14.0	21.0	23.0	20.0	16.0	HY-NVA
186	48	42.1	47.0	15.0	41.0	22.0	55.0	49.0	54.0	54.0	HY-NVA
187	48	34.1	38.0	62.0	10.0	56.0	38.0	1.0	34.0	34.0	HY-NVA
188	49	18.6	10.0	28.0	41.0	10.0	19.0	24.0	15.0	2.0	HY-NVA
189	49	35.9	44.0	32.0	12.0	68.0	41.0	6.0	69.0	15.0	HY-NVA
190	49	40.4	47.0	49.0	42.0	14.0	50.0	48.0	37.0	36.0	HY-NVA
191	50	42.1	76.0	18.0	42.0	36.0	21.0	14.0	65.0	65.0	HY-NVA
192	50	23.3	49.0	3.0	26.0	4.0	47.0	19.0	32.0	6.0	HY-NVA
193	50	15.3	1.0	30.0	25.0	26.0	6.0	11.0	17.0	6.0	HY-NVA
194	51	18.9	33.0	22.0	18.0	14.0	11.0	18.0	23.0	12.0	HY-NVA
195	51	2.3	2.0	2.0	0.0	2.0	3.0	4.0	3.0	2.0	HY-NVA
196	52	33.3	52.0	32.0	56.0	19.0	13.0	10.0	24.0	60.0	HY-NVA
197	52	25.5	10.0	30.0	16.0	25.0	17.0	38.0	38.0	30.0	HY-NVA
198	53	51.3	52.0	50.0	62.0	25.0	69.0	21.0	64.0	67.0	HY-NVA
199	53	20.3	6.0	12.0	14.0	19.0	4.0	23.0	49.0	35.0	HY-NVA
200	53	30.6	8.0	54.0	24.0	52.0	6.0	6.0	46.0	49.0	HY-NVA

Table M.1: All Hybrid Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
201	54	22.6	40.0	11.0	33.0	12.0	13.0	36.0	19.0	17.0	HY-NVA
202	54	13.9	11.0	25.0	14.0	19.0	23.0	3.0	14.0	2.0	HY-NVA
203	55	25.3	5.0	14.0	46.0	42.0	3.0	13.0	47.0	32.0	HY-NVA
204	55	57.9	71.0	54.0	49.0	38.0	65.0	66.0	75.0	45.0	HY-NVA
205	56	8.6	10.0	2.0	12.0	2.0	21.0	11.0	6.0	5.0	HY-NVA
206	56	52.9	12.0	34.0	77.0	95.0	54.0	43.0	83.0	25.0	HY-NVA
207	57	32.0	28.0	23.0	34.0	42.0	48.0	25.0	28.0	28.0	HY-NVA
208	57	50.4	13.0	84.0	62.0	24.0	74.0	56.0	8.0	82.0	HY-NVA
209	58	48.0	45.0	53.0	84.0	24.0	6.0	83.0	66.0	23.0	HY-NVA
210	59	22.0	36.0	29.0	16.0	20.0	6.0	28.0	39.0	2.0	HY-NVA
211	59	18.8	25.0	11.0	21.0	6.0	22.0	11.0	23.0	31.0	HY-NVA
212	60	32.3	43.0	39.0	21.0	40.0	21.0	43.0	8.0	43.0	HY-NVA
213	60	19.1	37.0	26.0	6.0	27.0	7.0	7.0	20.0	23.0	HY-NVA
214	61	44.3	78.0	77.0	62.0	19.0	61.0	9.0	41.0	7.0	HY-NVA
215	61	3.0	2.0	1.0	4.0	2.0	4.0	4.0	3.0	4.0	HY-NVA
216	62	42.4	46.0	70.0	9.0	1.0	86.0	61.0	57.0	9.0	HY-NVA
217	63	44.3	52.0	26.0	30.0	40.0	61.0	60.0	32.0	53.0	HY-NVA
218	63	47.8	56.0	10.0	36.0	64.0	61.0	55.0	64.0	36.0	HY-NVA
219	64	2.5	0.0	3.0	2.0	2.0	2.0	4.0	2.0	5.0	HY-NVA
220	65	28.6	41.0	17.0	24.0	21.0	32.0	38.0	31.0	25.0	HY-NVA
221	65	20.1	11.0	20.0	23.0	43.0	23.0	26.0	1.0	14.0	HY-NVA
222	66	21.4	23.0	33.0	27.0	3.0	30.0	2.0	25.0	28.0	HY-NVA
223	67	18.4	4.0	9.0	29.0	30.0	12.0	12.0	26.0	25.0	HY-NVA
224	68	10.1	10.0	8.0	15.0	3.0	11.0	17.0	8.0	9.0	HY-NVA
225	68	14.5	24.0	19.0	17.0	10.0	3.0	6.0	16.0	21.0	HY-NVA
226	69	60.1	110.0	34.0	59.0	73.0	57.0	25.0	37.0	86.0	HY-NVA
227	70	31.6	18.0	39.0	34.0	19.0	35.0	48.0	21.0	39.0	HY-NVA
228	71	18.5	17.0	12.0	22.0	4.0	9.0	35.0	21.0	28.0	HY-NVA
229	72	38.6	65.0	10.0	21.0	21.0	35.0	73.0	65.0	19.0	HY-NVA
230	73	49.0	43.0	96.0	43.0	78.0	51.0	12.0	51.0	18.0	HY-NVA
231	73	29.8	47.0	12.0	45.0	12.0	18.0	31.0	53.0	20.0	HY-NVA
232	74	65.4	48.0	65.0	125.0	21.0	64.0	115.0	46.0	39.0	HY-NVA
233	75	17.1	18.0	25.0	12.0	15.0	27.0	19.0	15.0	6.0	HY-NVA
234	76	45.8	86.0	19.0	58.0	60.0	55.0	53.0	19.0	16.0	HY-NVA
235	77	47.0	4.0	13.0	54.0	39.0	81.0	77.0	56.0	52.0	HY-NVA
236	78	34.3	54.0	46.0	51.0	49.0	27.0	25.0	18.0	4.0	HY-NVA
237	79	22.0	23.0	23.0	32.0	23.0	18.0	21.0	19.0	17.0	HY-NVA
238	80	4.4	4.0	2.0	4.0	4.0	8.0	2.0	5.0	6.0	HY-NVA
239	82	64.0	42.0	59.0	54.0	104.0	75.0	28.0	92.0	58.0	HY-NVA
240	83	26.0	41.0	36.0	29.0	8.0	32.0	53.0	2.0	7.0	HY-NVA
241	84	33.8	56.0	38.0	26.0	67.0	45.0	3.0	33.0	2.0	HY-NVA
242	85	18.4	27.0	17.0	30.0	6.0	19.0	25.0	15.0	8.0	HY-NVA
243	86	20.4	23.0	1.0	39.0	16.0	8.0	20.0	29.0	27.0	HY-NVA
244	88	100.0	129.0	77.0	138.0	112.0	141.0	50.0	110.0	43.0	HY-NVA
245	89	68.6	51.0	91.0	78.0	74.0	65.0	47.0	57.0	86.0	HY-NVA
246	91	1.9	0.0	0.0	2.0	2.0	3.0	2.0	4.0	2.0	HY-NVA
247	92	37.4	30.0	47.0	12.0	53.0	43.0	48.0	54.0	12.0	HY-NVA
248	94	33.6	56.0	64.0	35.0	5.0	38.0	7.0	45.0	19.0	HY-NVA
249	95	21.3	23.0	2.0	28.0	14.0	21.0	10.0	42.0	30.0	HY-NVA
250	97	82.9	98.0	17.0	131.0	112.0	85.0	21.0	99.0	100.0	HY-NVA
251	98	56.0	1.0	86.0	44.0	72.0	21.0	84.0	51.0	89.0	HY-NVA
252	100	42.0	91.0	30.0	9.0	19.0	77.0	34.0	3.0	73.0	HY-NVA
253	102	87.0	84.0	29.0	138.0	64.0	111.0	52.0	78.0	140.0	HY-NVA
254	104	36.4	19.0	4.0	54.0	15.0	51.0	44.0	53.0	51.0	HY-NVA
255	106	7.5	13.0	2.0	2.0	8.0	5.0	10.0	12.0	8.0	HY-NVA
256	108	85.4	76.0	116.0	91.0	102.0	118.0	62.0	43.0	75.0	HY-NVA
257	110	78.0	144.0	24.0	26.0	92.0	138.0	63.0	66.0	71.0	HY-NVA
258	112	89.4	110.0	63.0	9.0	141.0	167.0	110.0	77.0	38.0	HY-NVA
259	114	36.3	34.0	47.0	6.0	38.0	32.0	45.0	38.0	50.0	HY-NVA
260	117	25.1	7.0	34.0	25.0	35.0	24.0	30.0	10.0	36.0	HY-NVA

Table M.1: All Hybrid Example Data – Separate NVA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
261	119	54.6	49.0	67.0	49.0	86.0	44.0	21.0	20.0	101.0	HY-NVA
262	122	32.3	52.0	27.0	15.0	46.0	32.0	31.0	36.0	19.0	HY-NVA
263	125	79.4	151.0	81.0	19.0	56.0	101.0	132.0	31.0	64.0	HY-NVA
264	128	38.4	32.0	15.0	29.0	68.0	65.0	27.0	9.0	62.0	HY-NVA
265	131	28.1	24.0	28.0	31.0	32.0	39.0	33.0	27.0	11.0	HY-NVA
266	134	31.9	19.0	12.0	15.0	47.0	49.0	34.0	19.0	60.0	HY-NVA
267	138	86.1	176.0	71.0	46.0	17.0	47.0	4.0	123.0	205.0	HY-NVA
268	141	122.9	202.0	220.0	58.0	117.0	33.0	157.0	67.0	129.0	HY-NVA
269	145	129.4	132.0	223.0	68.0	26.0	177.0	117.0	106.0	186.0	HY-NVA
270	149	3.1	4.0	2.0	3.0	5.0	1.0	2.0	4.0	4.0	HY-NVA
271	154	113.6	145.0	205.0	153.0	87.0	36.0	167.0	43.0	73.0	HY-NVA
272	158	127.1	0.0	79.0	115.0	175.0	212.0	177.0	35.0	224.0	HY-NVA
273	163	32.9	24.0	28.0	46.0	13.0	45.0	49.0	45.0	13.0	HY-NVA
274	168	37.8	4.0	34.0	53.0	30.0	45.0	33.0	43.0	60.0	HY-NVA
275	174	83.8	91.0	52.0	56.0	86.0	91.0	110.0	65.0	119.0	HY-NVA
276	180	138.8	264.0	25.0	56.0	149.0	18.0	245.0	208.0	145.0	HY-NVA
277	187	144.1	137.0	167.0	30.0	128.0	147.0	175.0	203.0	166.0	HY-NVA
278	194	46.5	80.0	117.0	39.0	17.0	34.0	0.0	45.0	40.0	HY-NVA
279	202	11.6	6.0	20.0	9.0	7.0	3.0	17.0	10.0	21.0	HY-NVA
280	210	94.4	132.0	129.0	17.0	28.0	91.0	130.0	80.0	148.0	HY-NVA
281	219	32.0	18.0	31.0	32.0	67.0	29.0	9.0	53.0	17.0	HY-NVA
282	230	166.4	88.0	263.0	240.0	167.0	86.0	21.0	121.0	345.0	HY-NVA
283	241	18.8	16.0	44.0	4.0	26.0	9.0	3.0	23.0	25.0	HY-NVA
284	253	181.8	244.0	107.0	32.0	204.0	309.0	184.0	65.0	309.0	HY-NVA
285	267	91.5	73.0	122.0	50.0	106.0	64.0	125.0	67.0	125.0	HY-NVA
286	283	233.5	338.0	187.0	316.0	250.0	271.0	21.0	113.0	372.0	HY-NVA
287	301	79.0	98.0	125.0	31.0	117.0	49.0	129.0	0.0	83.0	HY-NVA
288	322	77.1	107.0	89.0	22.0	82.0	34.0	116.0	57.0	110.0	HY-NVA
289	346	250.6	497.0	225.0	283.0	22.0	329.0	513.0	81.0	55.0	HY-NVA
290	374	50.4	51.0	42.0	41.0	51.0	67.0	34.0	43.0	74.0	HY-NVA
291	408	123.9	117.0	214.0	174.0	112.0	123.0	115.0	15.0	121.0	HY-NVA
292	449	180.3	59.0	103.0	301.0	53.0	286.0	181.0	441.0	18.0	HY-NVA
293	500	44.0	84.0	34.0	46.0	2.0	86.0	7.0	57.0	36.0	HY-NVA
294	566	227.8	347.0	1.0	20.0	260.0	300.0	515.0	301.0	78.0	HY-NVA
295	654	466.4	179.0	437.0	801.0	471.0	592.0	110.0	715.0	426.0	HY-NVA
296	778	267.1	77.0	93.0	172.0	91.0	316.0	480.0	546.0	362.0	HY-NVA
297	968	142.3	259.0	293.0	2.0	58.0	1.0	207.0	211.0	107.0	HY-NVA
298	1300	466.6	665.0	17.0	864.0	702.0	373.0	88.0	803.0	221.0	HY-NVA
299	2060	1379.9	1436.0	1368.0	689.0	753.0	1316.0	1921.0	1633.0	1923.0	HY-NVA
300	20365	9147.1	11801.0	10074.0	710.0	15968.0	5799.0	13595.0	14260.0	970.0	HY-NVA

Table M.2: All Hybrid Example Data – Separate VA.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
1	21	15.1	14.0	5.0	14.0	23.0	26.0	35.0	3.0	1.0	HY-VA
2	21	5.3	2.0	8.0	6.0	8.0	6.0	3.0	6.0	3.0	HY-VA
3	21	19.5	23.0	28.0	3.0	30.0	0.0	21.0	29.0	22.0	HY-VA
4	21	4.5	4.0	3.0	5.0	6.0	5.0	5.0	5.0	3.0	HY-VA
5	21	14.5	12.0	14.0	17.0	15.0	13.0	7.0	21.0	17.0	HY-VA
6	21	3.8	4.0	3.0	5.0	4.0	3.0	2.0	5.0	4.0	HY-VA
7	21	12.3	18.0	20.0	21.0	6.0	3.0	2.0	18.0	10.0	HY-VA
8	21	5.9	6.0	3.0	9.0	1.0	5.0	7.0	8.0	8.0	HY-VA
9	21	11.4	2.0	5.0	21.0	13.0	7.0	5.0	19.0	19.0	HY-VA
10	21	3.4	3.0	5.0	3.0	3.0	3.0	2.0	5.0	3.0	HY-VA
11	21	2.0	0.0	0.0	3.0	3.0	1.0	3.0	3.0	3.0	HY-VA
12	22	3.9	4.0	6.0	4.0	7.0	2.0	2.0	4.0	2.0	HY-VA
13	22	14.5	10.0	6.0	14.0	17.0	8.0	22.0	18.0	21.0	HY-VA
14	22	5.4	10.0	7.0	10.0	2.0	3.0	6.0	4.0	1.0	HY-VA

Table M.2: All Hybrid Example Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
15	22	4.0	2.0	7.0	3.0	3.0	7.0	5.0	0.0	5.0	HY-VA
16	22	21.1	24.0	32.0	28.0	12.0	12.0	24.0	28.0	9.0	HY-VA
17	22	13.0	3.0	19.0	23.0	1.0	19.0	2.0	19.0	18.0	HY-VA
18	22	3.3	4.0	5.0	5.0	3.0	2.0	3.0	3.0	1.0	HY-VA
19	22	24.6	33.0	26.0	24.0	31.0	21.0	14.0	33.0	15.0	HY-VA
20	22	3.4	0.0	1.0	5.0	4.0	6.0	6.0	3.0	2.0	HY-VA
21	22	7.4	10.0	9.0	5.0	5.0	8.0	3.0	5.0	14.0	HY-VA
22	22	21.3	7.0	8.0	31.0	23.0	29.0	20.0	25.0	27.0	HY-VA
23	22	7.4	11.0	2.0	8.0	4.0	10.0	1.0	17.0	6.0	HY-VA
24	22	18.9	32.0	12.0	36.0	2.0	23.0	32.0	12.0	2.0	HY-VA
25	22	11.6	11.0	14.0	0.0	7.0	12.0	19.0	19.0	11.0	HY-VA
26	23	9.3	11.0	3.0	14.0	5.0	7.0	9.0	16.0	9.0	HY-VA
27	23	22.6	36.0	11.0	26.0	31.0	10.0	32.0	21.0	14.0	HY-VA
28	23	3.8	5.0	1.0	3.0	3.0	6.0	5.0	2.0	5.0	HY-VA
29	23	9.1	10.0	12.0	5.0	12.0	12.0	11.0	9.0	2.0	HY-VA
30	23	2.5	3.0	1.0	3.0	3.0	4.0	4.0	2.0	0.0	HY-VA
31	23	20.0	14.0	15.0	22.0	0.0	18.0	31.0	35.0	25.0	HY-VA
32	23	22.1	34.0	38.0	30.0	5.0	15.0	10.0	19.0	26.0	HY-VA
33	23	15.8	5.0	12.0	6.0	3.0	1.0	33.0	35.0	31.0	HY-VA
34	23	2.8	4.0	2.0	4.0	1.0	3.0	2.0	3.0	3.0	HY-VA
35	23	7.3	15.0	3.0	5.0	9.0	3.0	2.0	13.0	8.0	HY-VA
36	23	2.4	4.0	3.0	3.0	2.0	1.0	1.0	3.0	2.0	HY-VA
37	23	9.8	13.0	2.0	5.0	2.0	5.0	34.0	5.0	12.0	HY-VA
38	23	15.0	28.0	4.0	1.0	4.0	24.0	21.0	31.0	7.0	HY-VA
39	23	19.8	24.0	0.0	12.0	33.0	19.0	19.0	14.0	37.0	HY-VA
40	24	2.5	3.0	3.0	4.0	1.0	2.0	1.0	3.0	3.0	HY-VA
41	24	18.8	25.0	23.0	23.0	16.0	11.0	21.0	19.0	12.0	HY-VA
42	24	15.8	25.0	19.0	19.0	0.0	28.0	21.0	12.0	2.0	HY-VA
43	24	11.1	14.0	27.0	11.0	6.0	3.0	13.0	3.0	12.0	HY-VA
44	24	27.0	18.0	33.0	29.0	7.0	36.0	41.0	14.0	38.0	HY-VA
45	24	3.1	1.0	2.0	3.0	5.0	3.0	3.0	3.0	5.0	HY-VA
46	24	18.8	19.0	10.0	23.0	9.0	26.0	17.0	21.0	25.0	HY-VA
47	24	13.0	18.0	5.0	10.0	20.0	19.0	11.0	15.0	6.0	HY-VA
48	24	5.8	5.0	9.0	3.0	4.0	4.0	7.0	7.0	7.0	HY-VA
49	24	5.1	8.0	8.0	7.0	2.0	7.0	3.0	4.0	2.0	HY-VA
50	24	12.9	14.0	12.0	17.0	7.0	9.0	12.0	12.0	20.0	HY-VA
51	24	7.4	1.0	13.0	10.0	12.0	7.0	7.0	5.0	4.0	HY-VA
52	25	2.5	1.0	2.0	5.0	3.0	2.0	4.0	0.0	3.0	HY-VA
53	25	19.3	23.0	28.0	28.0	0.0	26.0	22.0	21.0	6.0	HY-VA
54	25	18.0	23.0	22.0	12.0	21.0	1.0	24.0	17.0	24.0	HY-VA
55	25	18.9	12.0	25.0	33.0	37.0	16.0	14.0	5.0	9.0	HY-VA
56	25	20.3	31.0	23.0	24.0	14.0	21.0	16.0	12.0	21.0	HY-VA
57	25	14.1	20.0	35.0	12.0	3.0	13.0	10.0	11.0	9.0	HY-VA
58	25	22.4	38.0	13.0	11.0	40.0	31.0	11.0	2.0	33.0	HY-VA
59	25	7.5	4.0	5.0	5.0	19.0	3.0	17.0	5.0	2.0	HY-VA
60	25	8.9	9.0	3.0	1.0	21.0	10.0	5.0	10.0	12.0	HY-VA
61	25	3.1	1.0	8.0	1.0	3.0	0.0	3.0	7.0	2.0	HY-VA
62	25	16.4	6.0	5.0	35.0	10.0	19.0	10.0	34.0	12.0	HY-VA
63	25	15.1	14.0	7.0	28.0	11.0	12.0	25.0	12.0	12.0	HY-VA
64	26	4.8	3.0	3.0	4.0	8.0	3.0	7.0	7.0	3.0	HY-VA
65	26	8.4	5.0	7.0	25.0	10.0	13.0	4.0	2.0	1.0	HY-VA
66	26	12.5	11.0	17.0	12.0	16.0	14.0	3.0	8.0	19.0	HY-VA
67	26	9.1	3.0	14.0	10.0	10.0	4.0	7.0	14.0	11.0	HY-VA
68	26	12.0	7.0	16.0	11.0	19.0	6.0	11.0	15.0	11.0	HY-VA
69	26	7.0	0.0	3.0	9.0	11.0	10.0	7.0	7.0	9.0	HY-VA
70	26	28.4	25.0	35.0	43.0	1.0	42.0	45.0	2.0	34.0	HY-VA
71	26	21.5	18.0	35.0	24.0	18.0	13.0	3.0	28.0	33.0	HY-VA
72	26	17.6	8.0	7.0	18.0	14.0	23.0	4.0	32.0	35.0	HY-VA
73	26	9.3	10.0	12.0	4.0	12.0	8.0	9.0	12.0	7.0	HY-VA
74	27	26.1	31.0	9.0	23.0	39.0	33.0	33.0	31.0	10.0	HY-VA

Table M.2: All Hybrid Example Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
75	27	6.1	7.0	1.0	7.0	6.0	7.0	10.0	1.0	10.0	HY-VA
76	27	15.6	17.0	9.0	21.0	6.0	1.0	3.0	49.0	19.0	HY-VA
77	27	24.5	34.0	35.0	4.0	27.0	31.0	8.0	24.0	33.0	HY-VA
78	27	16.9	19.0	21.0	3.0	19.0	19.0	9.0	15.0	30.0	HY-VA
79	27	17.5	21.0	12.0	1.0	19.0	6.0	31.0	19.0	31.0	HY-VA
80	27	18.3	19.0	24.0	25.0	36.0	13.0	1.0	27.0	1.0	HY-VA
81	27	5.5	9.0	2.0	11.0	4.0	3.0	5.0	7.0	3.0	HY-VA
82	27	24.1	24.0	27.0	30.0	28.0	13.0	28.0	28.0	15.0	HY-VA
83	28	29.4	44.0	33.0	41.0	22.0	37.0	29.0	1.0	28.0	HY-VA
84	28	17.5	27.0	2.0	25.0	17.0	12.0	14.0	26.0	17.0	HY-VA
85	28	8.5	4.0	1.0	17.0	9.0	1.0	21.0	3.0	12.0	HY-VA
86	28	18.8	5.0	21.0	12.0	37.0	21.0	28.0	9.0	17.0	HY-VA
87	28	4.4	0.0	4.0	7.0	7.0	3.0	6.0	8.0	0.0	HY-VA
88	28	10.9	13.0	6.0	23.0	1.0	3.0	6.0	5.0	30.0	HY-VA
89	28	2.1	6.0	3.0	0.0	1.0	1.0	1.0	3.0	2.0	HY-VA
90	28	16.5	24.0	19.0	7.0	3.0	26.0	30.0	14.0	9.0	HY-VA
91	28	23.0	24.0	3.0	32.0	34.0	41.0	2.0	25.0	23.0	HY-VA
92	29	24.6	19.0	28.0	31.0	40.0	18.0	9.0	14.0	38.0	HY-VA
93	29	22.1	7.0	28.0	27.0	31.0	3.0	15.0	34.0	32.0	HY-VA
94	29	10.9	7.0	9.0	19.0	9.0	2.0	12.0	17.0	12.0	HY-VA
95	29	22.1	28.0	15.0	5.0	6.0	42.0	42.0	19.0	20.0	HY-VA
96	29	23.8	21.0	33.0	39.0	12.0	37.0	28.0	4.0	16.0	HY-VA
97	29	23.6	20.0	10.0	5.0	21.0	31.0	36.0	40.0	26.0	HY-VA
98	29	7.4	12.0	10.0	10.0	5.0	0.0	13.0	9.0	0.0	HY-VA
99	29	11.0	10.0	16.0	1.0	19.0	5.0	10.0	6.0	21.0	HY-VA
100	29	28.4	50.0	9.0	42.0	17.0	28.0	25.0	39.0	17.0	HY-VA
101	30	15.3	20.0	13.0	21.0	2.0	28.0	28.0	3.0	7.0	HY-VA
102	30	16.3	3.0	12.0	22.0	23.0	11.0	17.0	16.0	26.0	HY-VA
103	30	14.5	26.0	14.0	2.0	16.0	26.0	0.0	20.0	12.0	HY-VA
104	30	16.3	17.0	19.0	3.0	14.0	24.0	14.0	22.0	17.0	HY-VA
105	30	11.4	12.0	14.0	14.0	5.0	18.0	9.0	8.0	11.0	HY-VA
106	30	5.1	7.0	3.0	6.0	5.0	4.0	4.0	3.0	9.0	HY-VA
107	30	3.5	8.0	3.0	3.0	5.0	3.0	2.0	0.0	4.0	HY-VA
108	31	14.9	12.0	12.0	14.0	16.0	10.0	11.0	32.0	12.0	HY-VA
109	31	2.5	4.0	3.0	3.0	3.0	1.0	4.0	0.0	2.0	HY-VA
110	31	24.8	10.0	42.0	38.0	6.0	33.0	33.0	19.0	17.0	HY-VA
111	31	16.0	12.0	10.0	5.0	30.0	8.0	21.0	14.0	28.0	HY-VA
112	31	23.8	21.0	13.0	1.0	13.0	44.0	33.0	26.0	39.0	HY-VA
113	31	21.0	21.0	14.0	23.0	33.0	26.0	22.0	22.0	7.0	HY-VA
114	31	5.3	6.0	1.0	2.0	11.0	4.0	3.0	5.0	10.0	HY-VA
115	32	2.0	2.0	1.0	3.0	3.0	1.0	3.0	1.0	2.0	HY-VA
116	32	14.1	17.0	11.0	21.0	7.0	20.0	5.0	15.0	17.0	HY-VA
117	32	22.1	17.0	27.0	5.0	33.0	36.0	5.0	52.0	2.0	HY-VA
118	32	21.5	0.0	21.0	11.0	11.0	46.0	40.0	15.0	28.0	HY-VA
119	32	7.9	11.0	3.0	17.0	1.0	9.0	4.0	6.0	12.0	HY-VA
120	32	22.1	15.0	15.0	28.0	14.0	5.0	29.0	36.0	35.0	HY-VA
121	32	14.0	5.0	7.0	22.0	21.0	21.0	9.0	8.0	19.0	HY-VA
122	33	18.9	44.0	1.0	33.0	5.0	12.0	39.0	7.0	10.0	HY-VA
123	33	18.9	26.0	26.0	2.0	8.0	14.0	54.0	7.0	14.0	HY-VA
124	33	13.4	9.0	3.0	23.0	7.0	6.0	28.0	17.0	14.0	HY-VA
125	33	19.5	19.0	33.0	29.0	27.0	19.0	17.0	7.0	5.0	HY-VA
126	33	20.1	35.0	31.0	32.0	15.0	24.0	7.0	14.0	3.0	HY-VA
127	33	3.5	3.0	3.0	7.0	1.0	3.0	1.0	7.0	3.0	HY-VA
128	34	24.1	14.0	17.0	31.0	30.0	24.0	31.0	1.0	45.0	HY-VA
129	34	10.1	3.0	16.0	5.0	7.0	19.0	11.0	12.0	8.0	HY-VA
130	34	15.6	18.0	28.0	26.0	14.0	3.0	9.0	12.0	15.0	HY-VA
131	34	29.5	5.0	42.0	29.0	56.0	34.0	3.0	50.0	17.0	HY-VA
132	34	14.1	7.0	19.0	17.0	14.0	10.0	20.0	15.0	11.0	HY-VA
133	34	3.4	2.0	3.0	7.0	6.0	3.0	3.0	3.0	0.0	HY-VA
134	35	6.4	0.0	6.0	7.0	9.0	4.0	9.0	7.0	9.0	HY-VA

Table M.2: All Hybrid Example Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
135	35	29.8	26.0	58.0	31.0	15.0	9.0	50.0	43.0	6.0	HY-VA
136	35	18.0	9.0	33.0	30.0	33.0	1.0	13.0	25.0	0.0	HY-VA
137	35	34.4	52.0	34.0	6.0	45.0	42.0	33.0	7.0	56.0	HY-VA
138	35	14.5	4.0	12.0	26.0	19.0	13.0	7.0	25.0	10.0	HY-VA
139	36	20.4	24.0	10.0	19.0	24.0	14.0	12.0	25.0	35.0	HY-VA
140	36	3.8	2.0	5.0	5.0	1.0	7.0	5.0	0.0	5.0	HY-VA
141	36	2.6	3.0	3.0	4.0	0.0	3.0	3.0	3.0	2.0	HY-VA
142	36	32.5	37.0	28.0	26.0	28.0	24.0	40.0	59.0	18.0	HY-VA
143	36	5.5	4.0	8.0	5.0	8.0	8.0	5.0	3.0	3.0	HY-VA
144	37	31.5	17.0	36.0	63.0	17.0	58.0	20.0	10.0	31.0	HY-VA
145	37	6.0	0.0	5.0	16.0	3.0	0.0	8.0	2.0	14.0	HY-VA
146	37	12.6	1.0	7.0	3.0	32.0	27.0	22.0	4.0	5.0	HY-VA
147	37	10.5	10.0	15.0	13.0	4.0	5.0	8.0	18.0	11.0	HY-VA
148	37	25.4	42.0	6.0	18.0	45.0	48.0	3.0	9.0	32.0	HY-VA
149	38	27.8	9.0	38.0	30.0	35.0	30.0	44.0	17.0	19.0	HY-VA
150	38	10.4	5.0	19.0	18.0	8.0	8.0	13.0	5.0	7.0	HY-VA
151	38	1.9	1.0	2.0	3.0	1.0	1.0	1.0	3.0	3.0	HY-VA
152	38	15.6	12.0	7.0	7.0	27.0	26.0	27.0	3.0	16.0	HY-VA
153	38	11.1	24.0	13.0	7.0	3.0	5.0	5.0	7.0	25.0	HY-VA
154	39	2.4	5.0	1.0	3.0	1.0	2.0	0.0	3.0	4.0	HY-VA
155	39	8.1	14.0	1.0	1.0	14.0	9.0	3.0	14.0	9.0	HY-VA
156	39	26.3	26.0	19.0	38.0	45.0	14.0	45.0	5.0	18.0	HY-VA
157	39	23.6	28.0	14.0	31.0	26.0	21.0	25.0	31.0	13.0	HY-VA
158	40	12.0	10.0	12.0	7.0	6.0	20.0	17.0	19.0	5.0	HY-VA
159	40	3.4	3.0	5.0	5.0	1.0	6.0	4.0	3.0	0.0	HY-VA
160	40	23.1	23.0	54.0	17.0	19.0	7.0	35.0	19.0	11.0	HY-VA
161	40	38.0	19.0	59.0	0.0	54.0	7.0	45.0	59.0	61.0	HY-VA
162	41	2.5	3.0	2.0	5.0	3.0	2.0	1.0	3.0	1.0	HY-VA
163	41	21.3	6.0	31.0	29.0	19.0	11.0	24.0	22.0	28.0	HY-VA
164	41	5.6	6.0	3.0	11.0	11.0	5.0	2.0	6.0	1.0	HY-VA
165	41	6.0	3.0	11.0	1.0	6.0	5.0	7.0	12.0	3.0	HY-VA
166	42	14.5	12.0	10.0	14.0	12.0	23.0	19.0	5.0	21.0	HY-VA
167	42	10.4	5.0	10.0	5.0	10.0	14.0	9.0	14.0	16.0	HY-VA
168	42	3.9	8.0	1.0	5.0	2.0	7.0	3.0	2.0	3.0	HY-VA
169	42	7.1	3.0	15.0	1.0	10.0	13.0	1.0	7.0	7.0	HY-VA
170	43	6.4	3.0	5.0	10.0	7.0	1.0	3.0	5.0	17.0	HY-VA
171	43	2.3	3.0	3.0	3.0	2.0	0.0	3.0	2.0	2.0	HY-VA
172	43	9.6	10.0	8.0	16.0	8.0	4.0	13.0	6.0	12.0	HY-VA
173	44	4.4	3.0	7.0	1.0	6.0	3.0	3.0	6.0	6.0	HY-VA
174	44	19.5	22.0	31.0	15.0	14.0	30.0	31.0	4.0	9.0	HY-VA
175	44	26.0	5.0	10.0	39.0	21.0	1.0	59.0	20.0	53.0	HY-VA
176	44	39.0	55.0	49.0	7.0	14.0	25.0	54.0	54.0	54.0	HY-VA
177	45	15.3	7.0	4.0	1.0	19.0	19.0	26.0	19.0	27.0	HY-VA
178	45	29.8	36.0	27.0	42.0	34.0	35.0	20.0	7.0	37.0	HY-VA
179	45	19.1	36.0	33.0	1.0	34.0	9.0	6.0	10.0	24.0	HY-VA
180	46	12.9	14.0	23.0	24.0	3.0	7.0	1.0	22.0	9.0	HY-VA
181	46	3.1	3.0	3.0	4.0	1.0	2.0	3.0	5.0	4.0	HY-VA
182	46	26.9	10.0	29.0	19.0	26.0	26.0	42.0	32.0	31.0	HY-VA
183	47	2.3	1.0	3.0	2.0	1.0	3.0	2.0	4.0	2.0	HY-VA
184	47	50.1	63.0	44.0	63.0	15.0	23.0	59.0	59.0	75.0	HY-VA
185	47	14.6	3.0	1.0	13.0	15.0	23.0	24.0	21.0	17.0	HY-VA
186	48	45.5	50.0	17.0	45.0	24.0	59.0	53.0	58.0	58.0	HY-VA
187	48	36.6	41.0	67.0	10.0	61.0	40.0	1.0	37.0	36.0	HY-VA
188	49	20.3	11.0	30.0	45.0	10.0	20.0	26.0	17.0	3.0	HY-VA
189	49	38.8	47.0	35.0	12.0	73.0	45.0	7.0	75.0	16.0	HY-VA
190	49	43.6	51.0	53.0	45.0	15.0	54.0	52.0	40.0	39.0	HY-VA
191	50	45.4	82.0	19.0	45.0	39.0	23.0	15.0	70.0	70.0	HY-VA
192	50	25.0	52.0	3.0	28.0	4.0	51.0	21.0	34.0	7.0	HY-VA
193	50	16.5	1.0	33.0	26.0	28.0	6.0	12.0	19.0	7.0	HY-VA
194	51	20.1	35.0	24.0	19.0	15.0	12.0	19.0	24.0	13.0	HY-VA

Table M.2: All Hybrid Example Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
195	51	2.5	2.0	3.0	0.0	2.0	3.0	4.0	3.0	3.0	HY-VA
196	52	35.9	56.0	34.0	61.0	21.0	14.0	10.0	26.0	65.0	HY-VA
197	52	27.3	11.0	32.0	17.0	26.0	19.0	41.0	40.0	32.0	HY-VA
198	53	55.1	56.0	54.0	66.0	27.0	74.0	23.0	68.0	73.0	HY-VA
199	53	22.0	6.0	13.0	15.0	21.0	5.0	25.0	53.0	38.0	HY-VA
200	53	32.6	8.0	58.0	26.0	56.0	6.0	6.0	49.0	52.0	HY-VA
201	54	24.1	43.0	12.0	35.0	12.0	14.0	38.0	21.0	18.0	HY-VA
202	54	14.9	12.0	27.0	15.0	20.0	25.0	3.0	15.0	2.0	HY-VA
203	55	27.0	5.0	15.0	49.0	45.0	3.0	14.0	51.0	34.0	HY-VA
204	55	62.3	77.0	58.0	53.0	41.0	70.0	71.0	80.0	48.0	HY-VA
205	56	9.1	11.0	3.0	12.0	2.0	22.0	12.0	6.0	5.0	HY-VA
206	56	57.0	13.0	37.0	83.0	103.0	58.0	47.0	89.0	26.0	HY-VA
207	57	34.1	30.0	24.0	36.0	45.0	52.0	26.0	30.0	30.0	HY-VA
208	57	54.4	14.0	91.0	67.0	26.0	80.0	60.0	9.0	88.0	HY-VA
209	58	51.6	48.0	57.0	90.0	26.0	7.0	89.0	71.0	25.0	HY-VA
210	59	23.6	38.0	31.0	17.0	21.0	6.0	31.0	42.0	3.0	HY-VA
211	59	20.3	27.0	12.0	23.0	7.0	24.0	12.0	24.0	33.0	HY-VA
212	60	34.9	47.0	42.0	22.0	43.0	23.0	47.0	9.0	46.0	HY-VA
213	60	20.3	40.0	28.0	6.0	29.0	7.0	7.0	21.0	24.0	HY-VA
214	61	47.6	84.0	83.0	66.0	20.0	66.0	10.0	45.0	7.0	HY-VA
215	61	3.4	3.0	1.0	4.0	2.0	4.0	5.0	3.0	5.0	HY-VA
216	62	45.6	49.0	75.0	10.0	1.0	93.0	66.0	61.0	10.0	HY-VA
217	63	47.8	56.0	28.0	33.0	43.0	66.0	65.0	34.0	57.0	HY-VA
218	63	51.3	61.0	11.0	39.0	68.0	66.0	59.0	68.0	38.0	HY-VA
219	64	2.8	0.0	3.0	3.0	2.0	2.0	4.0	3.0	5.0	HY-VA
220	65	31.0	45.0	19.0	26.0	22.0	35.0	41.0	33.0	27.0	HY-VA
221	65	21.5	12.0	21.0	24.0	46.0	25.0	28.0	1.0	15.0	HY-VA
222	66	22.8	24.0	35.0	29.0	3.0	32.0	2.0	27.0	30.0	HY-VA
223	67	19.8	5.0	10.0	31.0	33.0	12.0	12.0	28.0	27.0	HY-VA
224	68	10.8	11.0	8.0	16.0	3.0	12.0	18.0	8.0	10.0	HY-VA
225	68	15.5	26.0	21.0	18.0	11.0	3.0	6.0	17.0	22.0	HY-VA
226	69	64.8	119.0	36.0	63.0	79.0	61.0	27.0	40.0	93.0	HY-VA
227	70	34.1	19.0	42.0	37.0	20.0	38.0	52.0	23.0	42.0	HY-VA
228	71	20.1	18.0	13.0	24.0	5.0	10.0	38.0	22.0	31.0	HY-VA
229	72	41.5	70.0	10.0	23.0	22.0	38.0	79.0	70.0	20.0	HY-VA
230	73	52.6	46.0	103.0	47.0	84.0	55.0	12.0	55.0	19.0	HY-VA
231	73	31.6	51.0	12.0	48.0	12.0	19.0	33.0	57.0	21.0	HY-VA
232	74	70.5	52.0	70.0	135.0	23.0	69.0	124.0	49.0	42.0	HY-VA
233	75	18.4	19.0	26.0	13.0	16.0	29.0	21.0	17.0	6.0	HY-VA
234	76	49.1	93.0	20.0	63.0	64.0	59.0	57.0	20.0	17.0	HY-VA
235	77	50.9	5.0	14.0	59.0	42.0	87.0	83.0	61.0	56.0	HY-VA
236	78	36.6	58.0	49.0	54.0	53.0	29.0	26.0	19.0	5.0	HY-VA
237	79	23.4	24.0	25.0	34.0	25.0	19.0	22.0	20.0	18.0	HY-VA
238	80	4.8	5.0	2.0	5.0	4.0	8.0	2.0	5.0	7.0	HY-VA
239	82	69.0	45.0	63.0	59.0	112.0	81.0	30.0	99.0	63.0	HY-VA
240	83	27.9	44.0	38.0	31.0	9.0	34.0	57.0	3.0	7.0	HY-VA
241	84	36.3	60.0	40.0	28.0	73.0	48.0	3.0	35.0	3.0	HY-VA
242	85	19.9	29.0	18.0	33.0	7.0	20.0	26.0	17.0	9.0	HY-VA
243	86	21.8	25.0	1.0	42.0	17.0	8.0	21.0	31.0	29.0	HY-VA
244	88	107.8	139.0	82.0	149.0	120.0	152.0	54.0	119.0	47.0	HY-VA
245	89	73.8	54.0	98.0	84.0	80.0	70.0	50.0	61.0	93.0	HY-VA
246	91	2.1	0.0	0.0	2.0	3.0	3.0	2.0	4.0	3.0	HY-VA
247	92	40.4	33.0	51.0	12.0	57.0	47.0	52.0	58.0	13.0	HY-VA
248	94	36.1	60.0	68.0	38.0	5.0	41.0	7.0	49.0	21.0	HY-VA
249	95	23.0	24.0	3.0	31.0	15.0	23.0	10.0	45.0	33.0	HY-VA
250	97	88.9	105.0	18.0	141.0	120.0	91.0	22.0	106.0	108.0	HY-VA
251	98	60.1	1.0	93.0	47.0	77.0	22.0	91.0	54.0	96.0	HY-VA
252	100	45.0	98.0	33.0	10.0	20.0	82.0	36.0	3.0	78.0	HY-VA
253	102	93.5	91.0	31.0	149.0	68.0	119.0	56.0	84.0	150.0	HY-VA
254	104	39.1	20.0	5.0	58.0	16.0	55.0	47.0	57.0	55.0	HY-VA

Table M.2: All Hybrid Example Data – Separate VA *(continued)*.

			Week								
SKU	**Demand**	**Avg. Inv.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Dept.**
255	106	8.3	14.0	2.0	3.0	9.0	5.0	11.0	13.0	9.0	HY-VA
256	108	91.9	82.0	124.0	98.0	110.0	127.0	67.0	47.0	80.0	HY-VA
257	110	84.1	155.0	26.0	28.0	99.0	149.0	68.0	71.0	77.0	HY-VA
258	112	96.1	118.0	68.0	10.0	152.0	180.0	118.0	83.0	40.0	HY-VA
259	114	38.9	37.0	50.0	7.0	40.0	34.0	49.0	40.0	54.0	HY-VA
260	117	26.9	7.0	36.0	27.0	38.0	26.0	33.0	10.0	38.0	HY-VA
261	119	58.5	52.0	73.0	52.0	92.0	47.0	22.0	21.0	109.0	HY-VA
262	122	34.6	56.0	29.0	17.0	49.0	35.0	33.0	38.0	20.0	HY-VA
263	125	85.3	162.0	87.0	20.0	61.0	108.0	142.0	33.0	69.0	HY-VA
264	128	41.3	34.0	16.0	31.0	73.0	70.0	29.0	10.0	67.0	HY-VA
265	131	30.3	26.0	31.0	33.0	34.0	42.0	35.0	29.0	12.0	HY-VA
266	134	34.0	20.0	12.0	17.0	50.0	52.0	36.0	21.0	64.0	HY-VA
267	138	92.6	189.0	77.0	49.0	18.0	51.0	4.0	133.0	220.0	HY-VA
268	141	132.3	217.0	236.0	63.0	126.0	35.0	169.0	73.0	139.0	HY-VA
269	145	139.1	142.0	240.0	73.0	28.0	190.0	126.0	114.0	200.0	HY-VA
270	149	3.6	5.0	3.0	3.0	5.0	1.0	3.0	5.0	4.0	HY-VA
271	154	122.8	157.0	221.0	165.0	94.0	39.0	180.0	47.0	79.0	HY-VA
272	158	137.1	0.0	85.0	124.0	189.0	229.0	191.0	38.0	241.0	HY-VA
273	163	35.3	26.0	30.0	49.0	14.0	48.0	52.0	49.0	14.0	HY-VA
274	168	40.5	4.0	37.0	57.0	32.0	48.0	35.0	46.0	65.0	HY-VA
275	174	90.0	98.0	56.0	60.0	92.0	98.0	118.0	70.0	128.0	HY-VA
276	180	149.4	285.0	26.0	61.0	160.0	19.0	264.0	224.0	156.0	HY-VA
277	187	155.4	147.0	180.0	33.0	138.0	158.0	189.0	219.0	179.0	HY-VA
278	194	50.1	87.0	126.0	42.0	19.0	36.0	0.0	48.0	43.0	HY-VA
279	202	12.4	6.0	21.0	10.0	7.0	3.0	19.0	11.0	22.0	HY-VA
280	210	101.8	143.0	138.0	19.0	31.0	98.0	140.0	86.0	159.0	HY-VA
281	219	34.5	19.0	33.0	35.0	73.0	31.0	10.0	57.0	18.0	HY-VA
282	230	179.3	95.0	283.0	258.0	180.0	93.0	23.0	131.0	371.0	HY-VA
283	241	20.0	17.0	47.0	5.0	28.0	10.0	3.0	24.0	26.0	HY-VA
284	253	195.6	262.0	115.0	34.0	220.0	332.0	199.0	70.0	333.0	HY-VA
285	267	98.4	78.0	131.0	54.0	114.0	69.0	134.0	73.0	134.0	HY-VA
286	283	251.6	364.0	201.0	341.0	269.0	292.0	23.0	122.0	401.0	HY-VA
287	301	84.9	105.0	135.0	33.0	126.0	53.0	138.0	0.0	89.0	HY-VA
288	322	83.0	115.0	96.0	24.0	89.0	36.0	124.0	61.0	119.0	HY-VA
289	346	270.1	535.0	243.0	305.0	24.0	355.0	553.0	87.0	59.0	HY-VA
290	374	54.1	55.0	45.0	44.0	54.0	73.0	36.0	46.0	80.0	HY-VA
291	408	133.4	126.0	230.0	187.0	120.0	133.0	124.0	17.0	130.0	HY-VA
292	449	193.8	63.0	110.0	325.0	57.0	308.0	194.0	474.0	19.0	HY-VA
293	500	47.0	90.0	37.0	49.0	2.0	92.0	7.0	61.0	38.0	HY-VA
294	566	245.1	374.0	1.0	21.0	280.0	323.0	554.0	324.0	84.0	HY-VA
295	654	502.1	192.0	470.0	863.0	507.0	637.0	119.0	770.0	459.0	HY-VA
296	778	287.8	82.0	101.0	185.0	98.0	341.0	517.0	588.0	390.0	HY-VA
297	968	152.9	278.0	315.0	3.0	62.0	1.0	222.0	227.0	115.0	HY-VA
298	1300	502.6	717.0	18.0	930.0	756.0	402.0	95.0	865.0	238.0	HY-VA
299	2060	1486.0	1547.0	1473.0	742.0	811.0	1417.0	2069.0	1758.0	2071.0	HY-VA
300	20365	9850.6	12709.0	10849.0	765.0	17196.0	6245.0	14640.0	15357.0	1044.0	HY-VA

Appendix N

All Hybrid Example Tradeoff Results

In this appendix we present the tradeoff results for the all hybrid example. The first column represents the layout. A number in the first column represents the SKU which has been moved to the non-hybrid area. The column labeled "Total Dist/Tour" represents the distance per tour for the given layout. The column labeled "Retrievals/Hour per Operator" represents the number of retrievals per hour per operator for the given layout. The column labeled "Area" represents the area required for the given layout. The column labeled "Labor Cost" represents the total cost of labor for the given layout. The column labeled "WH Cost" represents the total cost of warehouse space for the given layout. The column labeled "Total Cost" represents the total cost of the given layout. The column labeled "Change" represents the change in cost from the previous layout.

Table N.1: All Hybrid Example Tradeoff Results.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
Combined	1544.71	9.32	32760	$268,179	$163,800	$431,979	
Separate	1213.24	11.87	44352	$210,632	$221,760	$432,392	
Initial HY	1544.71	9.32	32760	$268,179	$163,800	$431,979	
246	1544.05	9.33	40320	$268,063	$201,600	$469,663	-$37,684
270	1542.95	9.33	40320	$267,873	$201,600	$469,473	$191
219	1542.47	9.34	40320	$267,791	$201,600	$469,391	$82
183	1542.13	9.34	40320	$267,731	$201,600	$469,331	$60
195	1541.75	9.34	40320	$267,665	$201,600	$469,265	$66
171	1541.44	9.34	40320	$267,610	$201,600	$469,210	$55
151	1541.16	9.34	40320	$267,562	$201,600	$469,162	$49
215	1540.70	9.35	40320	$267,483	$201,600	$469,083	$79
115	1540.47	9.35	40320	$267,443	$201,600	$469,043	$40
162	1540.17	9.35	40320	$267,391	$201,600	$468,991	$52
154	1539.89	9.35	40320	$267,342	$201,600	$468,942	$49
238	1539.29	9.35	40320	$267,239	$201,600	$468,839	$103
141	1539.03	9.36	40320	$267,193	$201,600	$468,793	$46
181	1538.69	9.36	40320	$267,134	$201,600	$468,734	$59
279	1537.20	9.37	40320	$266,876	$201,600	$468,476	$258
89	1537.00	9.37	40320	$266,840	$201,600	$468,440	$36
109	1536.77	9.37	40320	$266,801	$201,600	$468,401	$39
255	1535.99	9.38	40320	$266,665	$201,600	$468,265	$135
159	1535.70	9.38	40320	$266,614	$201,600	$468,214	$51
11	1535.54	9.38	40320	$266,587	$201,600	$468,187	$27
133	1535.29	9.38	40320	$266,543	$201,600	$468,143	$44
283	1533.51	9.39	40320	$266,235	$201,600	$467,835	$308
52	1533.33	9.39	40320	$266,203	$201,600	$467,803	$31
36	1533.16	9.39	40320	$266,174	$201,600	$467,774	$30
168	1532.85	9.39	40320	$266,120	$201,600	$467,720	$54
30	1532.68	9.40	36288	$266,091	$181,440	$447,531	$20,189
173	1532.36	9.40	36288	$266,035	$181,440	$447,475	$56
40	1532.19	9.40	36288	$266,005	$181,440	$447,445	$30
127	1531.94	9.40	36288	$265,962	$181,440	$447,402	$43
293	1528.26	9.42	36288	$265,323	$181,440	$446,763	$639
140	1528.00	9.42	36288	$265,277	$181,440	$446,717	$46
107	1527.77	9.43	36288	$265,238	$181,440	$446,678	$39
34	1527.60	9.43	36288	$265,209	$181,440	$446,649	$30
45	1527.43	9.43	36288	$265,178	$181,440	$446,618	$31
61	1527.24	9.43	36288	$265,146	$181,440	$446,586	$32
18	1527.08	9.43	36288	$265,118	$181,440	$446,558	$28
164	1526.77	9.43	36288	$265,065	$181,440	$446,505	$53
165	1526.47	9.43	36288	$265,012	$181,440	$446,452	$53
10	1526.31	9.43	36288	$264,985	$181,440	$446,425	$27
170	1526.00	9.44	36288	$264,930	$181,440	$446,370	$55
20	1525.84	9.44	36288	$264,902	$181,440	$446,342	$28
143	1525.57	9.44	36288	$264,855	$181,440	$446,295	$46
28	1525.40	9.44	36288	$264,827	$181,440	$446,267	$29
290	1522.65	9.46	36288	$264,348	$181,440	$445,788	$478
87	1522.44	9.46	36288	$264,312	$181,440	$445,752	$36
224	1521.94	9.46	36288	$264,226	$181,440	$445,666	$86
6	1521.79	9.46	36288	$264,199	$181,440	$445,639	$27
106	1521.56	9.46	36288	$264,160	$181,440	$445,600	$39
114	1521.33	9.47	36288	$264,120	$181,440	$445,560	$40
145	1521.06	9.47	36288	$264,073	$181,440	$445,513	$47
205	1520.65	9.47	36288	$264,002	$181,440	$445,442	$71
281	1519.03	9.48	36288	$263,721	$181,440	$445,161	$281
297	1511.90	9.52	36288	$262,483	$181,440	$443,923	$1,238
12	1511.74	9.53	36288	$262,456	$181,440	$443,896	$28

Table N.1: All Hybrid Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
169	1511.43	9.53	36288	$262,401	$181,440	$443,841	$54
64	1511.24	9.53	36288	$262,369	$181,440	$443,809	$33
15	1511.08	9.53	36288	$262,341	$181,440	$443,781	$28
134	1510.83	9.53	36288	$262,297	$181,440	$443,737	$44
81	1510.63	9.53	36288	$262,262	$181,440	$443,702	$35
4	1510.47	9.53	36288	$262,235	$181,440	$443,675	$27
49	1510.29	9.53	36288	$262,204	$181,440	$443,644	$31
155	1510.01	9.54	36288	$262,154	$181,440	$443,594	$50
75	1509.81	9.54	36288	$262,120	$181,440	$443,560	$34
273	1508.61	9.55	36288	$261,911	$181,440	$443,351	$209
172	1508.29	9.55	36288	$261,856	$181,440	$443,296	$55
48	1508.11	9.55	36288	$261,825	$181,440	$443,265	$31
225	1507.61	9.55	36288	$261,737	$181,440	$443,177	$87
14	1507.45	9.55	36288	$261,710	$181,440	$443,150	$28
260	1506.59	9.56	36288	$261,560	$181,440	$443,000	$150
242	1505.96	9.56	36288	$261,451	$181,440	$442,891	$109
265	1504.99	9.57	36288	$261,284	$181,440	$442,724	$167
119	1504.76	9.57	36288	$261,243	$181,440	$442,683	$41
2	1504.60	9.57	36288	$261,216	$181,440	$442,656	$27
167	1504.30	9.57	36288	$261,162	$181,440	$442,602	$54
98	1504.08	9.57	36288	$261,125	$181,440	$442,565	$37
249	1503.38	9.58	36288	$261,003	$181,440	$442,443	$122
274	1502.14	9.59	36288	$260,788	$181,440	$442,228	$215
233	1501.58	9.59	36288	$260,692	$181,440	$442,132	$96
243	1500.95	9.59	36288	$260,581	$181,440	$442,021	$111
69	1500.75	9.60	36288	$260,548	$181,440	$441,988	$33
266	1499.77	9.60	36288	$260,376	$181,440	$441,816	$172
278	1498.34	9.61	36288	$260,128	$181,440	$441,568	$248
288	1495.97	9.63	36288	$259,716	$181,440	$441,156	$412
8	1495.81	9.63	36288	$259,689	$181,440	$441,129	$27
150	1495.53	9.63	36288	$259,641	$181,440	$441,081	$48
202	1495.13	9.63	36288	$259,571	$181,440	$441,011	$70
147	1494.86	9.63	36288	$259,524	$181,440	$440,964	$47
180	1494.52	9.64	36288	$259,465	$181,440	$440,905	$58
228	1494.00	9.64	36288	$259,375	$181,440	$440,815	$91
153	1493.72	9.64	36288	$259,326	$181,440	$440,766	$49
262	1492.82	9.65	36288	$259,169	$181,440	$440,609	$156
287	1490.60	9.66	36288	$258,784	$181,440	$440,224	$385
51	1490.42	9.66	36288	$258,753	$181,440	$440,193	$31
59	1490.23	9.66	36288	$258,721	$181,440	$440,161	$32
158	1489.94	9.66	36288	$258,670	$181,440	$440,110	$51
223	1489.45	9.67	36288	$258,585	$181,440	$440,025	$86
237	1488.86	9.67	36288	$258,483	$181,440	$439,923	$102
129	1488.61	9.67	36288	$258,440	$181,440	$439,880	$43
85	1488.41	9.67	36288	$258,405	$181,440	$439,845	$35
35	1488.24	9.68	36288	$258,375	$181,440	$439,815	$30
185	1487.89	9.68	36288	$258,314	$181,440	$439,754	$61
65	1487.70	9.68	36288	$258,282	$181,440	$439,722	$33
23	1487.54	9.68	36288	$258,253	$181,440	$439,693	$29
21	1487.37	9.68	36288	$258,225	$181,440	$439,665	$28
193	1487.00	9.68	36288	$258,160	$181,440	$439,600	$65
264	1486.06	9.69	36288	$257,997	$181,440	$439,437	$164
221	1485.58	9.69	36288	$257,913	$181,440	$439,353	$84
291	1482.57	9.71	36288	$257,391	$181,440	$438,831	$521
73	1482.38	9.71	36288	$257,358	$181,440	$438,798	$34
146	1482.11	9.72	36288	$257,310	$181,440	$438,750	$47
240	1481.50	9.72	36288	$257,205	$181,440	$438,645	$106

Table N.1: All Hybrid Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
213	1481.05	9.72	36288	$257,128	$181,440	$438,568	$77
60	1480.87	9.72	36288	$257,095	$181,440	$438,535	$32
211	1480.43	9.73	36288	$257,020	$181,440	$438,460	$76
177	1480.10	9.73	36288	$256,963	$181,440	$438,403	$57
67	1479.91	9.73	36288	$256,929	$181,440	$438,369	$33
259	1479.07	9.74	36288	$256,783	$181,440	$438,223	$146
166	1478.76	9.74	36288	$256,730	$181,440	$438,170	$53
222	1478.28	9.74	36288	$256,645	$181,440	$438,085	$85
94	1478.06	9.74	36288	$256,608	$181,440	$438,048	$37
105	1477.84	9.74	36288	$256,570	$181,440	$438,010	$39
285	1475.87	9.76	36288	$256,228	$181,440	$437,668	$342
99	1475.66	9.76	36288	$256,190	$181,440	$437,630	$38
296	1469.93	9.80	36288	$255,196	$181,440	$436,636	$995
88	1469.72	9.80	36288	$255,160	$181,440	$436,600	$36
254	1468.96	9.80	36288	$255,027	$181,440	$436,467	$133
248	1468.27	9.81	36288	$254,907	$181,440	$436,347	$120
29	1468.10	9.81	36288	$254,878	$181,440	$436,318	$29
298	1458.52	9.87	40320	$253,216	$201,600	$454,816	-$18,497
26	1458.36	9.87	40320	$253,187	$201,600	$454,787	$29
194	1457.98	9.88	40320	$253,122	$201,600	$454,722	$65
124	1457.74	9.88	40320	$253,080	$201,600	$454,680	$42
138	1457.48	9.88	40320	$253,035	$201,600	$454,635	$45
37	1457.31	9.88	40320	$253,005	$201,600	$454,605	$30
132	1457.05	9.88	40320	$252,961	$201,600	$454,561	$44
152	1456.77	9.88	40320	$252,912	$201,600	$454,512	$49
210	1456.34	9.89	40320	$252,837	$201,600	$454,437	$75
188	1455.98	9.89	40320	$252,775	$201,600	$454,375	$62
199	1455.59	9.89	40320	$252,707	$201,600	$454,307	$68
179	1455.26	9.90	40320	$252,649	$201,600	$454,249	$58
121	1455.02	9.90	40320	$252,608	$201,600	$454,208	$41
241	1454.40	9.90	40320	$252,500	$201,600	$454,100	$107
231	1453.86	9.90	40320	$252,407	$201,600	$454,007	$94
116	1453.63	9.91	40320	$252,366	$201,600	$453,966	$41
292	1450.32	9.93	40320	$251,792	$201,600	$453,392	$574
294	1446.15	9.96	36288	$251,068	$181,440	$432,508	$20,884
247	1445.48	9.96	36288	$250,951	$181,440	$432,391	$118
174	1445.15	9.96	36288	$250,895	$181,440	$432,335	$56
201	1444.76	9.97	36288	$250,826	$181,440	$432,266	$69
252	1444.02	9.97	36288	$250,698	$181,440	$432,138	$128
130	1443.77	9.97	36288	$250,654	$181,440	$432,094	$43
68	1443.58	9.98	36288	$250,621	$181,440	$432,061	$33
43	1443.40	9.98	36288	$250,591	$181,440	$432,031	$30
236	1442.83	9.98	36288	$250,491	$181,440	$431,931	$100
66	1442.64	9.98	36288	$250,458	$181,440	$431,898	$33
103	1442.42	9.98	36288	$250,419	$181,440	$431,859	$38
220	1441.94	9.99	36288	$250,337	$181,440	$431,777	$83
108	1441.71	9.99	36288	$250,298	$181,440	$431,738	$39
227	1441.20	9.99	36288	$250,208	$181,440	$431,648	$90
280	1439.65	10.00	36288	$249,939	$181,440	$431,379	$269
300	1289.64	11.17	48384	$223,895	$241,920	$465,815	-$34,436
203	1289.23	11.17	48384	$223,825	$241,920	$465,745	$70
261	1288.35	11.18	48384	$223,673	$241,920	$465,593	$153
192	1287.99	11.18	48384	$223,609	$241,920	$465,529	$64
25	1287.82	11.18	48384	$223,580	$241,920	$465,500	$29
111	1287.59	11.18	48384	$223,540	$241,920	$465,460	$40
101	1287.37	11.19	48384	$223,502	$241,920	$465,422	$38
136	1287.12	11.19	48384	$223,458	$241,920	$465,378	$45

Table N.1: All Hybrid Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
50	1286.94	11.19	48384	$223,426	$241,920	$465,346	$31
9	1286.78	11.19	48384	$223,399	$241,920	$465,319	$27
163	1286.48	11.19	48384	$223,347	$241,920	$465,267	$52
275	1285.20	11.20	48384	$223,124	$241,920	$465,044	$223
197	1284.81	11.21	48384	$223,058	$241,920	$464,978	$67
47	1284.63	11.21	48384	$223,027	$241,920	$464,947	$31
104	1284.41	11.21	48384	$222,988	$241,920	$464,908	$38
102	1284.19	11.21	48384	$222,950	$241,920	$464,870	$38
57	1284.01	11.21	48384	$222,918	$241,920	$464,838	$32
7	1283.85	11.22	48384	$222,891	$241,920	$464,811	$27
122	1283.61	11.22	48384	$222,850	$241,920	$464,770	$42
139	1283.35	11.22	48384	$222,804	$241,920	$464,724	$45
160	1283.06	11.22	48384	$222,753	$241,920	$464,673	$51
123	1282.82	11.23	48384	$222,711	$241,920	$464,631	$42
76	1282.62	11.23	48384	$222,677	$241,920	$464,597	$34
90	1282.41	11.23	48384	$222,641	$241,920	$464,561	$36
17	1282.25	11.23	48384	$222,613	$241,920	$464,533	$28
125	1282.00	11.23	48384	$222,570	$241,920	$464,490	$42
182	1281.66	11.24	48384	$222,511	$241,920	$464,431	$59
229	1281.14	11.24	48384	$222,419	$241,920	$464,339	$92
212	1280.70	11.24	48384	$222,343	$241,920	$464,263	$76
175	1280.37	11.25	48384	$222,287	$241,920	$464,207	$56
63	1280.18	11.25	48384	$222,254	$241,920	$464,174	$33
207	1279.76	11.25	48384	$222,181	$241,920	$464,101	$73
126	1279.52	11.25	48384	$222,139	$241,920	$464,059	$43
157	1279.23	11.26	48384	$222,088	$241,920	$464,008	$50
200	1278.84	11.26	48384	$222,020	$241,920	$463,940	$68
251	1278.11	11.27	48384	$221,894	$241,920	$463,814	$126
78	1277.91	11.27	48384	$221,860	$241,920	$463,780	$34
38	1277.74	11.27	48384	$221,830	$241,920	$463,750	$30
84	1277.54	11.27	48384	$221,794	$241,920	$463,714	$35
62	1277.35	11.27	48384	$221,762	$241,920	$463,682	$32
79	1277.15	11.28	48384	$221,727	$241,920	$463,647	$35
234	1276.59	11.28	48384	$221,630	$241,920	$463,550	$98
13	1276.43	11.28	48384	$221,602	$241,920	$463,522	$28
42	1276.25	11.28	48384	$221,572	$241,920	$463,492	$30
72	1276.06	11.28	48384	$221,538	$241,920	$463,458	$34
235	1275.49	11.29	48384	$221,439	$241,920	$463,359	$99
178	1275.16	11.29	48384	$221,382	$241,920	$463,302	$58
156	1274.87	11.30	48384	$221,332	$241,920	$463,252	$50
118	1274.63	11.30	48384	$221,291	$241,920	$463,211	$41
80	1274.43	11.30	48384	$221,256	$241,920	$463,176	$35
86	1274.23	11.30	48384	$221,220	$241,920	$463,140	$36
113	1274.00	11.30	48384	$221,180	$241,920	$463,100	$40
5	1273.84	11.30	48384	$221,153	$241,920	$463,073	$27
33	1273.67	11.31	48384	$221,124	$241,920	$463,044	$29
148	1273.40	11.31	48384	$221,076	$241,920	$462,996	$48
267	1272.38	11.32	48384	$220,900	$241,920	$462,820	$176
117	1272.15	11.32	48384	$220,859	$241,920	$462,779	$41
120	1271.91	11.32	48384	$220,818	$241,920	$462,738	$41
263	1270.99	11.33	48384	$220,658	$241,920	$462,578	$160
196	1270.61	11.33	48384	$220,592	$241,920	$462,512	$66
128	1270.36	11.34	48384	$220,549	$241,920	$462,469	$43
1	1270.21	11.34	48384	$220,523	$241,920	$462,443	$27
54	1270.03	11.34	48384	$220,491	$241,920	$462,411	$32
230	1269.49	11.34	48384	$220,398	$241,920	$462,318	$93
299	1254.32	11.48	48384	$217,764	$241,920	$459,684	$2,634

Table N.1: All Hybrid Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
149	1254.04	11.48	48384	$217,716	$241,920	$459,636	$48
216	1253.59	11.49	48384	$217,637	$241,920	$459,557	$79
112	1253.36	11.49	48384	$217,597	$241,920	$459,517	$40
55	1253.18	11.49	48384	$217,565	$241,920	$459,485	$32
187	1252.82	11.49	48384	$217,504	$241,920	$459,424	$62
217	1252.36	11.50	48384	$217,424	$241,920	$459,344	$80
95	1252.15	11.50	48384	$217,387	$241,920	$459,307	$37
93	1251.94	11.50	48384	$217,350	$241,920	$459,270	$37
257	1251.13	11.51	48384	$217,209	$241,920	$459,129	$141
53	1250.94	11.51	48384	$217,178	$241,920	$459,098	$31
46	1250.77	11.51	48384	$217,147	$241,920	$459,067	$31
295	1245.95	11.56	48384	$216,311	$241,920	$458,231	$836
284	1244.09	11.57	48384	$215,987	$241,920	$457,907	$324
41	1243.91	11.58	48384	$215,957	$241,920	$457,877	$30
214	1243.46	11.58	48384	$215,879	$241,920	$457,799	$78
282	1241.77	11.60	48384	$215,586	$241,920	$457,506	$294
289	1239.23	11.62	48384	$215,143	$241,920	$457,063	$442
189	1238.86	11.62	44352	$215,081	$221,760	$436,841	$20,223
110	1238.64	11.63	44352	$215,041	$221,760	$436,801	$39
91	1238.43	11.63	44352	$215,005	$221,760	$436,765	$36
271	1237.30	11.64	44352	$214,809	$221,760	$436,569	$196
56	1237.11	11.64	44352	$214,777	$221,760	$436,537	$32
97	1236.90	11.64	44352	$214,739	$221,760	$436,499	$37
218	1236.43	11.65	44352	$214,658	$221,760	$436,418	$81
96	1236.22	11.65	44352	$214,621	$221,760	$436,381	$37
71	1236.03	11.65	44352	$214,588	$221,760	$436,348	$34
39	1235.85	11.65	44352	$214,558	$221,760	$436,318	$30
24	1235.69	11.65	44352	$214,529	$221,760	$436,289	$29
245	1235.03	11.66	44352	$214,415	$221,760	$436,175	$114
276	1233.70	11.67	48384	$214,185	$241,920	$456,105	-$19,929
277	1232.33	11.69	48384	$213,946	$241,920	$455,866	$239
239	1231.73	11.69	48384	$213,841	$241,920	$455,761	$104
135	1231.47	11.69	48384	$213,797	$241,920	$455,717	$44
256	1230.68	11.70	48384	$213,659	$241,920	$455,579	$138
144	1230.41	11.70	48384	$213,612	$241,920	$455,532	$47
258	1229.58	11.71	48384	$213,469	$241,920	$455,389	$143
92	1229.37	11.71	48384	$213,432	$241,920	$455,352	$36
131	1229.12	11.72	48384	$213,389	$241,920	$455,309	$44
31	1228.95	11.72	48384	$213,360	$241,920	$455,280	$29
272	1227.79	11.73	48384	$213,157	$241,920	$455,077	$202
82	1227.58	11.73	48384	$213,122	$241,920	$455,042	$35
176	1227.26	11.73	48384	$213,065	$241,920	$454,985	$57
190	1226.89	11.74	48384	$213,002	$241,920	$454,922	$63
58	1226.71	11.74	48384	$212,970	$241,920	$454,890	$32
209	1226.28	11.74	48384	$212,896	$241,920	$454,816	$74
142	1226.02	11.75	48384	$212,850	$241,920	$454,770	$46
286	1223.93	11.77	48384	$212,488	$241,920	$454,408	$362
77	1223.73	11.77	48384	$212,453	$241,920	$454,373	$34
191	1223.37	11.77	48384	$212,390	$241,920	$454,310	$64
3	1223.21	11.77	48384	$212,363	$241,920	$454,283	$27
253	1222.46	11.78	48384	$212,233	$241,920	$454,153	$130
250	1221.75	11.79	48384	$212,109	$241,920	$454,029	$124
226	1221.24	11.79	48384	$212,021	$241,920	$453,941	$88
161	1220.94	11.79	48384	$211,969	$241,920	$453,889	$52
268	1219.90	11.80	48384	$211,788	$241,920	$453,708	$181
22	1219.74	11.81	48384	$211,760	$241,920	$453,680	$28
208	1219.31	11.81	48384	$211,686	$241,920	$453,606	$73

Table N.1: All Hybrid Example Tradeoff Results *(continued)*.

	Total Dist/Tour	Retrievals/Hour per Operator	Area	Labor Cost	WH Cost	Total Cost	Change
186	1218.96	11.81	48384	$211,625	$241,920	$453,545	$61
232	1218.41	11.82	48384	$211,530	$241,920	$453,450	$95
32	1218.25	11.82	48384	$211,501	$241,920	$453,421	$29
100	1218.03	11.82	48384	$211,463	$241,920	$453,383	$38
16	1217.87	11.82	48384	$211,435	$241,920	$453,355	$28
269	1216.80	11.83	48384	$211,250	$241,920	$453,170	$186
74	1216.60	11.84	48384	$211,216	$241,920	$453,136	$34
137	1216.34	11.84	48384	$211,171	$241,920	$453,091	$45
27	1216.18	11.84	48384	$211,142	$241,920	$453,062	$29
206	1215.76	11.84	48384	$211,070	$241,920	$452,990	$72
198	1215.37	11.85	48384	$211,003	$241,920	$452,923	$67
184	1215.03	11.85	48384	$210,942	$241,920	$452,862	$60
83	1214.83	11.85	48384	$210,907	$241,920	$452,827	$35
70	1214.63	11.86	48384	$210,874	$241,920	$452,794	$33
19	1214.47	11.86	48384	$210,846	$241,920	$452,766	$28
44	1214.29	11.86	48384	$210,815	$241,920	$452,735	$31
204	1213.89	11.86	48384	$210,744	$241,920	$452,664	$71
244	1213.24	11.87	44352	$210,632	$221,760	$432,392	$20,272

Vita

John F. Klote was born November 7, 1974 in Alexandria, VA. He was awarded his B.S. in Civil Engineering (May, 1996) and Master of Engineering Administration (May, 1997) from Virginia Tech. He worked as an industrial engineer for Tefen USA in manufacturing facilities located in Maine, Indiana, Pennsylvania, and Florida from 1997 to 1999.

John is currently a graduate student in the Grado Department of Industrial and Systems Engineering at Virginia Tech. During his graduate studies, John served as a research assistant for Cross Creek Apparel, Inc.'s main distribution center in Mt. Airy, NC. John developed operator evaluation software, examined forward and reserve department operations, and evaluated automatic sorter performance for a project co-funded by the National Science Foundation. John will graduate with his Master of Science in Manufacturing Systems Engineering in May, 2001.