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An Analysis of Factors Affecting the Cost of
Returnable Logistical Packaging Systems

presented by

Sangjin Lee

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Master degree in Packaging

Major professor

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AN ANALYSIS OF FACTORS AFFECTING THE COST OF RETURNABLE LOGISTICAL PACKAGING SYSTEMS

By

Sangjin Lee

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

School of Packaging

1999

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ABSTRACT

AN ANALYSIS OF FACTORS AFFECTING THE COST OF RETURNABLE LOGISTICAL PACKAGING SYSTEMS

By

Sangjin Lee

This paper develops a cost model and simulation to explore the effect of six variables on the cost of returnable packaging systems and the trade-off existing in the use of collapsible/nestable returnable containers. The six variables are 1) cycle time, 2) average daily volume, 3) peak volume factor, 4) pack quantity, 5) delivery distance, and 6) container unit cost. It finds that the significant cost drivers are the container unit cost, delivery distance, average daily volume, and pack quantity. The effect of cycle time and peak volume factor is low relative to the others. A production and logistics profile is developed to visualize and improve the cost justification of returnable container systems. It also finds that the return ratio of one-to-fifteen (1:15) balances the trade-off between the increase in packaging cost and the decrease in transportation cost.

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I dedicate this paper to my parents who always have been there for me.

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ACKNOWLEDGMENTS

I would like to express my appreciation and gratitude to those who have contributed to the development of this research. I would like to wish a most sincere thanks to my major professor, Dr. Twede for the great support and encouragement. I also like to thank my committee members, Dr. Closs for the thesis idea and guidance, and Dr. Burgess for the directions through methodology. I also like to record the acknowledgements to GM Powertrain, Livonia Engine Plant for the great internship opportunity, and to Pete Warner, my mentor during the internship, for your considerations.

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CHAPTER 1

INTRODUCTION

As more and more companies find economic benefits of returnable container systems over expendable packaging, several studies have addressed the economic justification of returnable packaging systems (Block 1999, Turvey 1998, Kibler 1997, Cozart 1997, and Findlay 1997). These studies compare the cost of the two types of packaging systems for a particular product with a specific manufacturing and logistics system. The studies have been the basis for manufacturers to make the decision to either stay with expendables or change to a returnable packaging system.

These studies, however, do not generalize the container systems' costs in relation to the other products and their various manufacturing and logistics structures. The need exists for research to develop generalized rules for determining when returnable container systems are cost effective.

This paper evaluates returnable container systems, container costs, and the resulting total logistics costs. The research objective is to quantitatively document how activities of reverse logistics affect levels of costs in various manufacturing and logistics systems, focusing on the following questions:

1. What are the significant cost drivers in reusable packaging systems?
2. What is the effect of each cost driver on total packaging system cost?
3. What is the optimal return ratio in the use of nestable/collapsible returnable containers?

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4. What are the appropriate production and logistics structures for the returnable container systems?

Activity-based costing systems are applied as a tool to identify each activity and its cost drivers involved in a distribution packaging system (Wiersema 1995). Two cost functions, one for each packaging system, are developed for the purpose of cost comparison. Next, a cost simulation is performed under varying conditions of production and logistics. The cost simulation can specify a relevant range of production and logistics settings, so that economics of returnable container system can be evaluated. This research will help to identify systems that favor returnable packaging. It can be used to design a reverse material flow system by specifying the cost drivers in order to achieve an efficient system for returnable containers.

It is important to analyze the role of each component as a part of the total system and consider its influence on the performance of the entire manufacturing system. The designer of a material flow system is faced not only with the specification of individual system components but also the association between components and the interaction of the material flow system with the manufacturing system itself. Individual system design may be optimal in itself, but if the design cannot be integrated into the overall supply chain system, it may have a negative impact on the manufacturing system performance. The design of material flow systems is required to achieve a comprehensive set of goals by keeping track of a large amount of information. This set of goals indicates the number of de

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number of dependent decisions that have to be incorporated in the design or analysis of any supply network.

The second chapter of this thesis reviews the supporting literature regarding the economics and environmental benefits of returnable container systems. The third chapter describes the cost models and the cost simulation methodology. Chapter 4 reports the results and Chapter 5 discusses the implications.

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CHAPTER 2

LITERATURE REVIEW

This review begins with a discussion of the returnable containers. It discusses the role that will be played by reverse logistics in the future, including the use of returnable packaging systems. The remainder of the literature review discusses six variables known to affect the cost of returnable packaging systems: 1) cycle time, 2) average daily volume, 3) peak volume factor, 4) pack quantity, 5) delivery distance, and 6) container unit cost.

RETURNABLE CONTAINERS

Reverse logistics may be applied to several stages of the logistic chain. Both the materials management part and the physical distribution part of the logistic chain are potential areas of application. Reverse logistics systems pull products and/or packaging back from the point of use to specific facilities. This application of reverse distribution systems can be found most for supporting product recall, exchange, and repair programs. Increasingly, however, reverse distribution systems are designed to reuse or recycle secondary packaging materials and to a lesser extent recover products and primary packaging materials (Kopicky et al 1993).

Opportunities for reducing the amount of packaging material vary, depending on the type of packaging involved. While packaging may exist in different types, such as containers, pallets, slipsheets, or bottles, depending on its major pur

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its major purpose, it is convenient to categorize containers. Packaging falls into two categories, consumer packaging, and industrial packaging.

Consumer packaging is basic packaging that physically holds a product (e.g., soup can, soda bottle, soap powder box) and is intended to provide the consumer ease of use until the product is consumed. This consumer packaging is designed to contain and protect the product and to appeal to consumers and stimulate product sales. Sometimes additional secondary packaging is designed to facilitate self-service sales, to prevent theft, to further advertise and market the product, or to facilitate use by the consumer (e.g., toothpaste box, six-pack carrier).

Consumer packaging waste is the primary target for waste recycling legislation because most of it has traditionally been landfilled. This is because household waste involves heterogeneous materials and is the result of complex shopping behavior, resulting in high costs to recycle. Reuse of consumer packaging is problematic at best due to sanitation, logistical and behavioral obstacles (Twede 1995).

Industrial packaging (also called "distribution packaging," "logistical packaging," and transport packaging") is packaging used for packaging products during transport from a sender to a recipient, either in retail or industry (Stock 1992). Industrial packaging often represents boxes, crates, pallets, banding, and void fill packaging (e.g., polystyrene "peanuts") with great emphasis on protection, ergonomics, and shipping consideration. This type of container is usually designed for single or multiple use, depending on its destination. If it can be used o

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be used only once, they are defined as one-way packaging material. Unlike consumer packaging, industrial packaging is made for relatively homogenous materials and is regularly recycled as a matter of business practice, to reduce waste disposal costs (Twede 1995).

Returnable industrial packaging is a type of secondary packaging that can be used more than once in the same form. This thesis studies the application of reverse logistics in the area of physical distribution: the reuse of logistical packaging material.

BENEFITS OF RETURNABLE CONTAINERS

The use of returnable containers is one of the solutions that industry has come up with for our growing environmental concern. This development is stimulated by a growing responsibility towards the environment and regulations from the government in many European countries. But, this is not the case in the US, where the use of returnable containers has been driven by economics.

Substantial amount of anecdotal evidence indicates that returnable packaging systems can have great cost savings over expendable container systems (Witt 1986, 1994, 1993; Auguston 1993; Andel 1995; Karen 1997; Pashall 1986; Trunk 1995). For example, John Deere & Co. has invested $20 million in a returnable container program with its suppliers of assembly parts expecting a positive cash payoff (Andel 1993). Another example is Herman Miller Inc., which has saved more than $600,000 during 2 years of returnable container practice. IBM, Ford, General Motors, and Toyota have also succes

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successfully implemented a returnable container system and reduced packaging cost (Witt 1993; Auguston 1993).

The economic benefit becomes possible mainly due to the longer life of returnable containers. When the cost of a returnable container is amortized over its life, the cost of packaging material can become lower, even with its higher initial cost, than that of a disposable container (see Table 1). However, the cost of packaging is not the only cost factor making savings possible because of the dynamic nature of activities involved in reverse logistics systems for reusable containers.

Table 1 Lifetime Cost Comparison of One-Way and Reusable 2-cubic Foot Shipping Containers, by Material ("How to Select Shipping Containers" 1991)

	Corrugated One-way	Corrugated Resuable	Plastic Reusable
Weight (pounds)	1.5	2.2	5.5
Initial cost	$0.53	$1.06	$11.03
Estimated life (number of trips)	1	5	250
Cost per trip (average)	$0.53	$0.21	$0.044

RETURNABLE CONTAINER SYSTEMS

The nature of returnable container systems is dynamic, as it becomes a two-way flow system. For example, a large number of parts are shipped from suppliers to customers. Several activities take place. First parts have to be packed, then loaded on a transport i.e. truck. They travel either directly to the plant, to another supplier or to a consolidation center. Upon arrival to a specific dock door, the parts go into storage where they are physically stored until the point of use. The empty containers then have to be returned to their point of origin for re

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origin for reuse either by retracing the steps in the opposite order or by shipping through a separate container return logistical system (Huettner 1998). This distribution system can be even more complex if the number of participants increases.

This number of activities that make up the distribution system, and the costs of most logistical operations are affected by packaging. Packaging cost affects the cost of packing, handling, transport, storage and unpacking operations for all channel members. The use of returnable containers eliminates a disposal costs and the need to repeatedly purchase packaging. In most cases, it also reduces logistical operation costs since the returnable containers can be designed to increase cubic efficiency for transport and storage as well as ease packing, handling and unpacking. On the other hand, it requires a large initial investment, additional transport costs and the need for empty container sorting operations (Twede 1999).

Several studies have addressed cost-justification of returnable container systems. Findlay (1997) and Turvey (1998) proposed a cost model that estimated the cost of corrugated and plastic containers for use within the Ontario fresh produce industry. Cozart (1997) has done a similar study for automobile industry, Kibler's study (1997) was in the furniture industry, and Block (1999) investigated medical device packaging alternatives. These studies present a comprehensive and clear understanding of the cost infrastructure of the defined container options. Most of them employed the activity based costing method used in this thesis. These studies, however, were limited to comparing specific reusable s

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reusable shipping containers as an alternative to single-use transport packaging in a specific system.

Returnable container systems cannot be a direct substitute for the expendable container systems. Each firm works with different products that associated with unique market, customer, and facilities. It is necessary for the individual firm to develop a logistics system that is optimal for itself. In some cases, reusable shipping containers are an integral part of inbound supply chains regardless of their cost (Meagher 1998). It is important for a firm to understand how logistical factors affect the container system costs.

Because of the activities involved and container's compatibility with the supply chain strategy, the use of returnable containers does not always result in lower overall physical distribution costs than expendable containers. A number of other factors affect the overall system cost including type of packaging used, transportation, handling and labor and disposal costs.

Packaging Cost

The cost of packaging material in general varies widely and depends on the material, the level of protection desired for product, and marketing requirements. With some products, for which no merchandising considerations enter into the selection of the package (such as parts for automobile manufacturing), the packaging cost is usually based on the level of protection required for the product. The cost of distribution packaging for expensive electronic components, for example, may represent a small fraction of the product cost. The packaging cost for shipments of cement, on the other hand, may be m

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may be much greater relative to the product cost. The level of protection for cement may be set to anticipate a certain percentage of product loss in shipment because the cost of replacing this loss may be less than the cost of improving packaging to provide full protection (Saphire 1994).

In general, the returnable containers can provide better protection than the expendables and reduce shipping damage due to greater container strength (Pashall 1986). However, investing in a set of returnable containers requires a much larger initial investment than would be needed to buy one-way containers. The unit cost of returnable container is higher and the adequate number of containers that must be purchased at the onset to account for the fact that the distribution pipeline must be stocked at all times (Auguston 1995). The initial investment in the container fleet depends on the four major factors: 1) Cycle time 2) Average Daily Volume 3) Peak Volume Factor 4) Pack Quantity.

Cycle Time

The container cycle time refers to the total time it takes for a complete loop between the supplier and the customer. Table 3 represents a typical cycle. Containers are filled in one day. Filled containers are stocked for four days, ready for the shipment at supplier. They will then be loaded onto a truck and delivered to the customer in one day. The containers are stored till the point of use for four days. The consumption of the parts inside the containers takes place on the production line for one day. Empty containers at the end of the production line are stored at the customer location for 5 days and are sorted to return to the supplier for reuse. Then, containers are shipped back (one day) and for th

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and for three days await refilling. In this case, the cycle time for the complete loop is twenty days.

Table 2 Container Cycle Time (Cozart 1997)

AT SUPPLIER		IN TRANSPORT		AT CUSTOMER	
Full containers	4 days	Full containers to customer	1 day	Full containers	4 days
Container in process	1 day			Container in process	1 day
Empty containers	3 days	Empty containers from customer	1 day	Empty containers	5 days

The cycle time is known to be the important cost determinant. When the container turnovers are speeded up, containers gain with a relatively short payback period (Trunk 1993). The shorter the cycle time, the lower the initial cost investment (low quantities to be purchased), and vice versa.

Since the returnable container system requires a high initial investment, the cycle time tends to be underestimated in the attempt to lower the initial investment. Calculating the right cycle time is important. If the cycle time is underestimated, there will be a lack of containers. If the cycle time is overestimated, money will be wasted on excess containers sitting around doing nothing.

In order to measure the accurate cycle time, it would be practical to use general process chart. Using a process flow chart is a technique for documenting activities in a detailed, compact, and graphic form to understand the process (Melnyk and Denzler 1996). Table 4 is a collection of general activities involved in the packaging cycle time as an example of the process chart. By filling in the time required per activity, a fairly accurate cycle time can be measured

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measured. The flow through the process can be shown by connecting the symbols. This technique cannot only help to calculate an accurate cycle time, but can improve the cycle time by eliminating redundant or unnecessary activities.

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At Customer	●
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Table 3 Calculation of Cycle Time Using General Process Chart

	Activities	Time	Description
At Supplier	● ■ ➡ ◗ ▼		Locate correct returnables in warehouse
	● ■ ➡ ◗ ▼		Transfer stored returnables to packaging line
	● ■ ➡ ◗ ▼		Remove totes from pallet and prepare for use (cleaning, check for usability)
	● ■ ➡ ◗ ▼		Pack product into tote
	● ■ ➡ ◗ ▼		Unitize tote on pallet
	● ■ ➡ ◗ ▼		Inventory finished goods
	● ■ ➡ ◗ ▼		Locate the product ordered
	● ■ ➡ ◗ ▼		Transfer to loading dock
	● ■ ➡ ◗ ▼		Load product onto trailer
	● ■ ➡ ◗ ▼		Ship product to customer
At Customer	● ■ ➡ ◗ ▼		Unload product pallets from truck
	● ■ ➡ ◗ ▼		Transfer into inventory
	● ■ ➡ ◗ ▼		Transfer product to assembly line
	● ■ ➡ ◗ ▼		Open totes
	● ■ ➡ ◗ ▼		Remove product from tote and use in assembly process
	● ■ ➡ ◗ ▼		Stage empty tote for collection
	● ■ ➡ ◗ ▼		Collect and transfer empty totes to staging/sorting area
	● ■ ➡ ◗ ▼		Sort empty totes by customer and it own kind
	● ■ ➡ ◗ ▼		Stage empty totes for supplier pick up
	● ■ ➡ ◗ ▼		Transfer empty totes to loading dock
	● ■ ➡ ◗ ▼		Transfer empty totes onto truck trailer
Beginning of Supplier Cycle	● ■ ➡ ◗ ▼		Ship empty totes back to supplier
	● ■ ➡ ◗ ▼		Unload empty totes from truck
	● ■ ➡ ◗ ▼		Transfer them to sorting and accounting area
	● ■ ➡ ◗ ▼		Inspect each tote for cleanliness, damage, and separate if necessary
	● ■ ➡ ◗ ▼		Re unitize totes for storage
	● ■ ➡ ◗ ▼		Transfer pallet of totes into inventory location
	● ■ ➡ ◗ ▼		Enter number of totes, type, and location for inventory account program
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Average Daily Volume

The average daily volume represents the demand for the packed items over a period of time divided by the total workdays during that period. The expected impact of the average daily volume on the container system cost is as the daily volume goes up, the total system cost should go up, but at a decreasing rate. This impact of average daily usage on the container system cost can be referred to as the economies of scale existing in the production costs and tapering principle in the transportation costs (Bowersox and Closs 1996).

For example, if the daily volume increases, more containers have to be purchased. As a consequence, the initial container investment increases, but the unit cost of container decreases because the high setup costs diminish over the large production quantities. In comparison of the expendable with the returnable container systems' costs, the sensitivity of reaction, as a total system cost, should be different from each other.

The average daily volume affects the both of container systems in the same way. However, the degree of reaction to the average daily volume should be different from each other. The expendable container cost, as a cost per part, should not be affected by average daily volume but by pack quantity only. The container cost per part depends on the number of part quantities in that container. The actual cost impact of average daily volume for the expendable container system is in the transportation cost.

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On the other hand, the returnable container cost, as a cost per part, should be affected by the average daily volume since the initial investment in the container fleet depends on the initial container quantities and the initial container quantities depends on the average daily volume. In addition, the returnable container cost is amortized by its useful life and pack quantity.

Peak Daily Volume

Demand variation with time is a result of growth or decline in sales rates, seasonality in the demand pattern, and general fluctuations caused by a multiple of factors (Ballou 1998). The demand variation is an important element of cycle time. Cycles with little variation are best for the returnable container systems (Twede 1999). When there is a lot of variation, the inventory of containers has to be large enough to cover the largest volume cycle in order to prevent container stock out and under estimation of the initial investment.

The use of peak volume instead of average volume does not always give accurate container quantities. The use of peak volume is more suitable for products with the relatively long duration of peak demand. If, for example, the actual volume for a product draws a sine curve that has the highest and lowest volume can be canceled each other within one cycle, it is recommended to use the average daily volume rather than the peak volume. For example, the cycle time is about 20 days, the anticipated average volume is about 500 products per day, and a container holds 50 products, the average container consumption per day would be 200 containers. As shown in the Figure 1, the fluctuation in the daily volu

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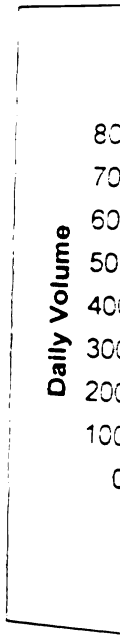

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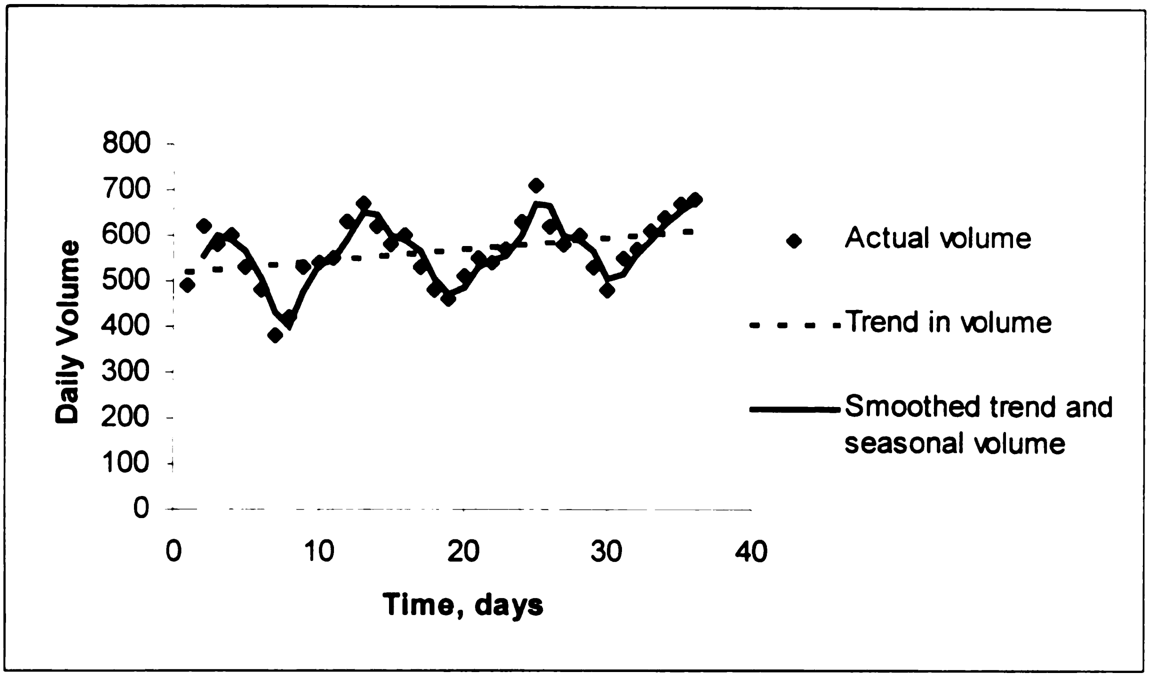
daily volume is about ±100 parts, equivalent to ±20 containers, along the average trend line. This fluctuation doesn't affect the initial container quantities.

Figure 1 An example of a random demand pattern with both trend and seasonal elements (Ballou 1998)



Pack Quantity

The pack quantity represents the number of products per standard container pack. Pack quantity should be an important factor in packaging costs when looking at the packaging cost in proportion to the number of parts per container. The more products per container, the cheaper the packaging cost becomes.

The pack quantity affects both container systems' cost in same way. Since the unit cost of returnable containers is more expensive than that of expendables, the decreasing rate should be higher for the returnable containers than the expendables when the pack quantity increases.

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The use of returnable containers is known for an ideal solution when materials are delivered in small lot size quantities directly to the manufacturing line. This is one of the applications in just-in-time (JIT) production, which have encouraged the returnable container system. JIT reduces the number of returnable containers required by increasing the speed of the inventory replenishment cycle (cycle time) (Twede 1999). If the pack quantity can be smaller with the support of quick change over, the smaller pack quantity should be more justifiable for the returnable container system.

TRANSPORTATION COST: MOTOR CARRIER

Cost of transport service to a shipper is simply the line-haul rate for transporting goods plus any accessorial or terminal charges for additional service provided. In the case of for-hire service, the rate charged for the movement of goods between two points plus any additional charges, such as for pickup at origin, delivery at destination, insurance, or preparing the goods for shipment, make up the total cost of service. When the shipper owns the service, the cost of service is an allocation of the relevant costs to the shipment in question. Relevant costs include such items as fuel, labor, maintenance, depreciation of equipment, and administrative costs (Bowersox and Closs 1996).

Two basic economic considerations influence the cost of transport: (1) the size of a shipment, and (2) the length of haul. Each of these basic considerations are briefly discussed.

As a general rule, the larger a shipment is, the lower the cost-per-hundredweight (CWT) per unit of distance (Bowersox and Closs 1996).

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Distributing the fixed costs over greater volume generally reduces the per-unit costs. The fixed costs, pickup and delivery platform handling, and billing and collecting, are highly sensitive to shipment sizes below 2,000 to 3,000 pounds. The fixed costs for shipments larger than 3,000 pounds continue to drop as pickup and delivery and handling costs are spread over the larger shipment sizes. This impact of shipment size on transportation cost is often referred to as the quantity discount (economies of scale), which is typically classified as truckload (TL) or less than truckload (LTL).

A general rule for the rate associated with delivery distance is that the longer the haul, the lower the cost per unit of distance. The impact of distance on transport cost is traditionally referred to as the tapering principle. Because the terminal charges are often included in line-haul charges, a rate structure that follows costs will show rates increasing with distance but at a decreasing rate (Bowersox and Closs 1996). In other words, the terminal costs and other fixed charges are distributed over miles as the delivery distance increases. Another rate that can be found common is proportional rate. For those carriers with the significant line-haul cost components, a compromise between rate structure simplicity and service costs is provided by the proportional rate structure (Ballou 1998). This simple structure adversely discriminates against the long-haul shipper in favor of the short-haul shipper. Terminal charges are not recovered on the short haul. Truckload rates can have this characteristic because handling costs are minimal.

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Distance is a critical issue for returnable container systems. Transportation cost is always higher for returnable container systems because of return transportation. This report examines distance-related rates for truckload quantities.

OTHER IMPORTANT COSTS

The container's life is critical data for the returnable container system cost. The container's life depends on the strength of the material and the container construction. Steel and plastic have a longer life than wooden packages. There are some tests can be used for estimation. However, the information concerning container life is not reliable enough. The number of trips also depends on the number lost (Rosenau 1996).

Labor cost is related to the process of shipping and handling goods. The process of shipping goods may involve the participation of many parties at different points. The labor cost, as a function of time, must be increasing as the number of activities is increasing.

The following procedures are found common in the process of shipping components from a supplier to an assembly factory:

1. erecting and packing containers
2. placing individual containers into bulk units on pallets or slipsheets
3. moving unitized loads to shipping docks
4. loading and unloading trucks
5. transporting unit loads from shipping docks to storage or assembly areas
6. fitting individual containers onto assembly line equipment

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These are common procedures for both expendable and returnable container systems.

The difference in the labor cost between these two container systems is the time involved in three activities:

7. container assembly
8. disposing for expendable container systems
9. sorting empty containers for returnable container systems and loading trucks for return.

There is no general rule that tells which one of the two container systems requires less labor. It varies from industry to industry depending on packaging design and its ergonomics. I have learned, during my internship experience at GM Powertrain in 1999 that returnable container systems can be less labor-intensive than expendable containers. The time involved in cutting open and disposing the expendable containers usually takes as twice as the time consumed for sorting the returnable containers.

Storage space is another factor. In comparison between expendable and returnable container systems, it is true that the empty returnable containers require more space than is necessary for the expendables. However, as long as a facility already has the available space, there should not be any additional storage cost. If extra space is needed, there would be an additional carrying cost.

Expendable container systems entail costs related to recycling or disposal. The disposal costs include charges for special handling equipment (compactors and bailer

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and bailers), material pickup and disposal, and labor to sort and place items in appropriate waste containers, compactors, or bailers. However, expendable package recycling can also generate revenue.

The returnable container systems, however, don't have any costs associated with recycling or disposing. Usually, the regrind services are available at no charge. A different set of costs associated with the returnable container system would be the cost of cleaning and repairing containers (Saphire 1994).

This section discussed some other important costs in the returnable container systems. It is hard to generalize the complexity involved in these variances. In addition, the amount of simulation results would be too large that the number of variables must to be limited. Thus, the fixed values are to be used for these costs. The fixed values will be further discussed in the Chapter 3.

COLLAPSIBILITY/NESTABILITY

Returnable containers may be designed with features that reduce the cost of shipping, handling, and storaging empty containers, including (Saphire 1994):

- Collapsibility: The walls of the container are designed to fold down when collapsed.
- Nestability: Empty containers can easily be placed into one another.

These features allow for a reduction in the space that empty containers take up in transportation and storage, and allow for more containers to be hauled back than were delivered full (Auguston 1993).

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For companies with limited storage space, collapsibility/nestability is an advantage. However, some companies utilizing the features in order to minimize return transportation cost may find that more containers must be purchased. Since empty containers are generally stockpiled until a full truckload can be returned, more collapsed/nested will be required in the system than if the containers were returned fully erected.

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CHAPTER 3

METHODOLOGY

This section describes cost models and the simulations used in this research. Two sets of cost models, one for each container system, were developed for the purpose of cost comparison. The cost models were then used as a basis of cost simulations. First, a single variable cost simulation was used to measure the impact of the six cost drivers on the container systems' costs. Second, a multi-variable cost simulation was designed to capture the impact of multiple variables at once. A multiple regression analysis was applied to the results of the multi-variable cost simulation in order to identify the individual independent (six cost drivers) which had the greatest impact on the three measures of performance. A manufacturing and logistics system profile was developed, which can reveal when savings can be achieved over expendable container systems.

A separate analysis was used in order to determine the optimal return ratio in use of nestable/collapsible containers. A discussion of the two cost models, parameters and dynamics follows. The results are provided in Chapter 4.

EXPENDABLE CONTAINER SYSTEM COST (ECSC)

Four types of cost were identified to be important in expendable container systems.

1. container cost
2. transportation cost

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3. labor cost

4. disposal cost

The expendable container system cost *ECSC* in \$/part is the sum of the four types of cost:

$$ECSC = ECC + TCE + LCE + DCE \tag{1}$$

where

ECC = expendable container cost, \$/part

TCE = transportation cost for expendable container system, \$/part

LCE = labor cost for expendable container system, \$/part

DCE = disposal cost for expendable container system, \$/part

For the sake of comparison later in the cost simulation between expendable and returnable container system costs, all units of cost models will be represented as \$/part.

Expendable Container Cost (ECC)

The expendable container cost *ECC* as \$/part can be given by unit cost of an expendable container *UCE* over standard pack *PQ*:

$$ECC = \frac{UCE}{PQ} = \frac{\text{\$/container}}{\text{parts/container}} = \text{\$/part} \tag{2}$$

where

ECC = expendable container cost per product, \$/part

UCE = unit cost of an expendable container, \$/container

PQ = pack quantity: part quantity per container, part/container

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If, for example, a container holds 30 parts and the container unit cost is \$3.00, the expected expendable container cost *ECC* is *ECC* = \$3.00/container ÷ 30 parts/container = \$0.10/part. It should be noted that the unit cost of an expendable container includes the cost of materials, such as pallets, labels, tape, and stretch wrap. Suppose, for example, the cost of a container is \$0.99. The cost of tape to seal the bottom and the top plus one label on the side is \$0.01. Twenty of these containers will be unitized on a pallet and the cost of pallet is \$39.50. After palletizing, the package requires stretch wrapping and a master label. The stretch wrapping and the master label cost \$0.50 together, so that the cost of the pallet, stretch wrap, and label is \$40 ÷ 20 = \$2 per part. Thus, the actual unit cost an expendable container *CE* would be \$0.99 + \$0.01 + \$2 = \$3.00/part in this e.g.

Transportation Cost for Expendable Container Systems (TCE)

Whether it is for expendable or returnable container systems, transportation cost should be in proportion to the delivery distance *DD*: $TCE = R \times DD$, where *R* is the constant rate per mile. The cost of *TCE* per part can be proposed as:

$$TCE = \frac{R \times DD}{FOS \times ADV} = \frac{\frac{\$}{\text{mile}} \times \text{miles}}{\text{days} \times \frac{\text{parts}}{\text{day}}} = \$/\text{part} \qquad (3)$$

where

FOS = frequency of supply, days

ADV = average daily volume, parts/day

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The frequency of supply *FOS* represents how often the deliveries are made between the shipper and the consignee. For example, if delivery takes place once every four days, frequency of supply is 4 ÷ 1 = 4 days, and if delivery takes everyday, frequency of supple is 1, and if delivery takes four times per day, frequency of supply would be 1 ÷ 4 = 0.25 days, and so on. It should be noted that the frequency of supply could not be longer than the container cycle time. The reason is that the cycle time includes at least one delivery from supplier to customer. If frequency of supply is greater than cycle time, there would be no delivery between supplier and customer.

Suppose, for example, a trucking company with a rate of $1.40/mile delivers 100 parts of average daily volume from supplier to customer. The cycle time between supplier and customer is 20 days long and they are 1000 miles apart from each other. Thus, the transportation cost would be $1.40/mile × 1000 miles ÷ 1 day ÷ 100 parts = $14/part.

Labor Cost for Expendable Container Systems (LCE)

Labor cost is driven by the amount of time involved in the set of activities. Thus, labor cost can be expressed as

$$LCE = TE \times \frac{LR}{PQ} = \frac{\text{hours}}{\text{container}} \times \frac{\frac{\$}{\text{hour}}}{\frac{\text{parts}}{\text{container}}} = \$/\text{part} \qquad (4)$$

where

LCE = labor cost for expendable, $/part

TE = time needed to handle expendable container, hours/container

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LR = labor rate per hour, \$/hour

PQ = pack quantity, parts/container

Suppose, for example, a plant consumes an average time of 0.84 minutes or 0.84 ÷ 60 = 0.014 hours per expendable container from packing at a shipper to the point of disposal at a consignee. The pack quantity is 20 parts per container and the hourly rate is \$12.00. Thus, the expected labor cost for such an expendable container system would be 0.014 hours/container × \$12/hour ÷ 20 parts/container = \$0.0084/part. If labor rate is different for each activity, the calculation should break down to individual activity. For example, if packing takes 0.005 hours per container and the hourly rate is \$8, and unpacking and disposing takes 0.009 hours per container and the hourly rate is \$12, the calculation would be (0.005 hours/container × \$8/hour + 0.009 hours/container × \$12/hour) ÷ 20 parts/container = 0.0074/part.

Disposal Cost for Expendable Container Systems (DCE)

Disposal cost should be in proportion to the amount of material to be disposed. Thus, the disposal cost for an expendable container system DCE can be expressed as

$$DCE = \frac{DR \times CW}{PQ} = \frac{\frac{\$}{\text{lb}} \times \frac{\text{lbs}}{\text{container}}}{\frac{\text{parts}}{\text{container}}} = \$/\text{part} \qquad (5)$$

where

DCE = disposal cost, \$/part

DR = disposal rate per lb, \$/lb

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CW = container weight, lbs/container

PQ = pack quantity, parts/container

Suppose, for example, a container with a tare weight of 3 pounds holds 20 parts, and the disposal charge is $0.0475 per pound. Thus, the disposal cost DC is $0.0475/lbs × 3 lbs/container ÷ 20 parts/container = $0.007125/part. It should be noted that this model does not account for any revenue from recycling.

So;

$$ECSC = \frac{UCE}{PQ} + \frac{R \times DD}{FOS \times ADV} + TE \times \frac{LR}{PQ} + \frac{DR \times CW}{PQ} = \$/\text{part} \qquad (6)$$

RETURNABLE CONTAINER SYSTEM COST (RCSC)

Three types of cost have been identified to be important in returnable container systems.

1. container cost
2. transportation cost
3. labor cost

The returnable container system cost $RCSC$ in $/part is the sum of the three types of cost:

$$RCSC = RCC + TCR + LCR \qquad (7)$$

where

RCC = returnable container cost, $/part

TCR = transportation cost for returnable container system, $/part

LCR = labor cost for returnable container system, $/part cost in

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From the literature review, it is known that there is virtually no disposal cost involved in returnable container systems.

Returnable Container Cost (RCC)

A returnable container system requires a certain number of containers *N* to begin with. The number of returnable containers *N* is expected to handle the anticipated amount of material flow during the time period of the containers life. Assuming that *AV* is annual volume and container life is *CL* in years, the returnable container cost *RCC* in per part units can be expressed as:

$$RCC = \frac{\text{Container cost}}{\text{Product quantity}} = \frac{UCR \times N}{AV \times CL} = \frac{\frac{\$}{\text{container}} \times \text{containers}}{\frac{\text{parts}}{\text{year}} \times \text{years}} = \$/\text{part} \tag{8}$$

where

RCC = returnable container cost, \$/part

UCR = unit cost of returnable container, \$/container

N = initial container quantities to be purchased, containers

AV = annual volume, parts/year

CL = container life, years

The important task here is to establish the initial container quantity to be purchased *N*. *N*, in other words, is number of containers required to hold a number of products during the container cycle time *CT*: $N = \frac{CT \times ADV}{PQ}$, where *PQ* is pack quantity representing quantity of products per container and *ADV* is average daily volume. In reality, however, not all containers can make it through their lifetime. Some of the containers must be damaged, stolen, or misplaced, and they will have to be replaced with new containers. The container return rate *CRR*, as percentage of *N*, can capture these unexpected situations: $N = \frac{CT \times ADV}{PQ} \times CRR$. In addition, there must be variations in daily volume. Peak volume factor *PVF* is a multiple factor used to capture the variations in the daily volume: $PVF = \frac{PDV}{ADV}$, where *PDV* is the anticipated peak daily volume. Thus, the number of containers is: $N = \frac{CT \times ADV}{PQ} \times CRR \times PVF$. Thus, returnable container cost *RCC* becomes:

$$RCC = \frac{UCR \times \left(\frac{CT \times ADV}{PQ} \times CRR \times PVF \right)}{AV \times CL} \tag{9}$$

Suppose, for example, the returnable container unit cost is \$5.00 and the expected useful life of a container is 2 years. Due to the harsh distribution environments, 30 percent of the containers are expected to get stolen, damaged, or misplaced. Again, the unit cost represents all the material costs involved in shipping containers. Due to the stable stackability, stretch wrapping may not be required. However, the cost of the label and a fraction of pallet cost must be included if the containers are palletized. This container has pack quantity *PQ* of 10 parts. The average consumption of the product in a day is 100 parts. Due to the production variation, the manufacturer anticipates peak consumption to be 150 parts. Based on the anticipated peak daily volume, the cycle time is calculated to be 20 days. The official working days of this plant are 250 days per year. Thus, the returnable packaging cost is \$5.00/container × 20 days × 100 parts/day ÷ 10 parts/container × 1.3 × 1.5 ÷ 25000 parts/year ÷ 2 years = \$0.03/part.

Transportation Cost for Returnable Container System (TCR)

The transportation cost for a returnable container system is the same as that of an expendable container system plus additional charges for back hauling empty containers. These charges are for the extended delivery distance from customer back to supplier plus charges for stoppage. However, the mileage rate for a returnable container system is often lower than the rate for an expendable container system. It is usually 20 ~ 40 % cheaper depending on the amount of transported goods. Assuming that the discount rate is fixed at 30 %, the transportation cost for a returnable container can be proposed as:

$$TCR = \frac{R \times 0.7 \times DD \times 2 + NS \times SR}{FOS \times ADV} = \$/\text{part} \qquad (10)$$

where

TCR = transportation cost for returnable container system, \$/part

$R \times 0.7$ = rate per mile including discount rate of 30 %, \$/mile

$DD \times 2$ = delivery distance (round trip), miles

NS = number of stoppages, stops

SR = stoppage rate, \$/stop

FOS = frequency of supply, days

ADV = average daily volume, parts/day

The term $R \times 0.7$ represents the discount mileage rate at 30%. The term $DD \times 2$ represents the extended delivery distance for the back hauling. It should be noted that sometimes the charges for inbound and outbound transportation is different because the inbound transport is for full containers and the outbound transport is for empty containers. The transportation cost model in this study represents one fixed rate with 30% discounts for both inbound and outbound transports. Usually this is the case when a company hires a third party company for the dedicated transportation service.

If, for example, in the same situation as the expendable container system, one stoppage and \$50 per stoppage, the transportation cost for the returnable container system *TCR* would be (\$1.40/mile × 0.7 × 1000 miles × 2 + 1 stop × \$50/stop) ÷ 1 day ÷ 100 parts = \$20.1/part.

Labor Cost (LCR)

The labor cost can be proposed as it was in the expendable container system *LCE* previously. The labor cost between the expendable and returnable container systems becomes different because each system requires a different set of activities. Thus, the labor cost for the returnable container system *LCR* is:

$$LCR = TR \times \frac{LR}{PQ} = \$/\text{part} \qquad (11)$$

where

TR = time needed to handle returnable container, hours/container

So;

$$RCSC = \frac{UCR \times \left(\frac{CT \times ADV}{PQ} \times CRR \times PVF \right)}{AV \times CL} + \frac{MR \times 0.7 \times DD \times 2 + NS \times SR}{FOS \times ADV}$$

$$+ TR \times \frac{LR}{PQ} = \$/\text{part}$$

(12)

RETURN RATIO (R_r)

In the use of collapsible or nestable returnable containers, two important cost functions can be found:

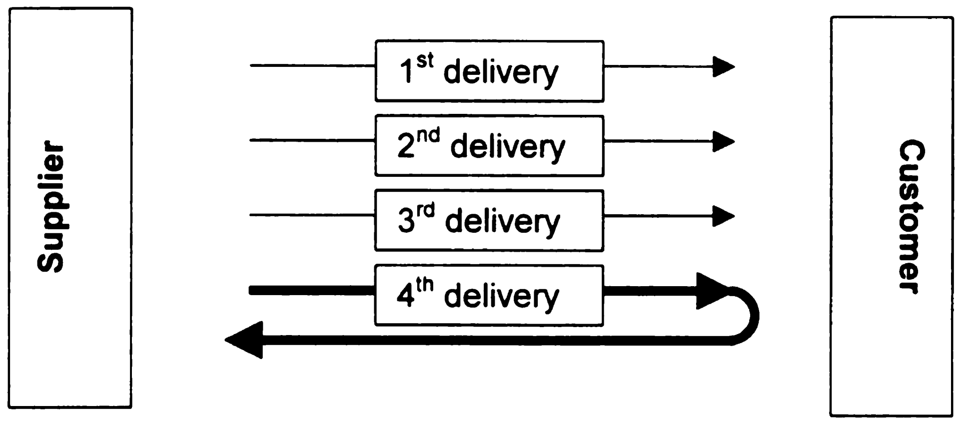
1. cost of transportation C_t
2. cost of containers C_c (for additional containers for holding days)

Using collapsible/nestable containers reduces the transportation cost by maximizing the cubic efficiency. On the other hand, more containers are needed since no empty containers are returning to the supplier while waiting for the truck to be fully loaded. Intuitively, it can be assumed that as R_r increases, C_t decreases and C_c increases. Trade-offs can be made to find the best compromise such that the total cost C_T reduces to a minimum.

$$C_T(R_r) = C_t(R_r) + C_c(R_r) \quad (13)$$

The expected situation when utilizing collapsible returnable containers isthat the supplier receives the same number of trailerloads as it ships, on a one-to-one basis, and that it avoids shipping packages back LTL. If, for example, the return ratio is one-to-four, and the supplier delivers once every day, then the supplier would be receiving the empties back every four days. Figure 2 shows that three out of four deliveries are not closed loop.

Figure 2 Transportation cost associated with return ratio



Thus, the transportation cost should be based on the one-way rate for the first through third deliveries and the two-way rate for the fourth delivery. To capture this relationship, the transportation cost can be calculated by a combination of the transportation cost for expendable container system and returnable container system:

$$C_t(R_r) = aT(1 - R_r) + bTR_r = aT - aTR_r + bTR_r \qquad (14)$$

where

a = cost per one-way trip, \$/trip

T = number of trips over the time period of container life, trips/year

b = cost per two-way trip, \$/trip

A further definition of these terms is:

a = \$/mile × mile = $R \times DD$ as in TCE previously

b = \$/mile × 0.7 × mile × 2 = $MR \times 0.7 \times DD \times 2$ as in TCR previously

$T(1 - R_r)$ = number of one-way deliveries out of the total number of trips in a container's life

TR_r = number of two-way deliveries out of total number of trips in a container's life

Container cost C_c is for the additional containers to the given float of returnable container. For example, if a float of returnable containers was determined for a 20-day cycle time based on a daily delivery basis using a one-to-one return ratio, the number of returnable containers based on one-to-four return ratios would make the cycle time 23 days, adding two extra days of holding empty containers with the customer. This additional cost C_c can be expressed:

$$C_c(R_r) = \frac{cQ(R_r^{-1} - 1)}{l} = \frac{cQ}{l} R_r^{-1} - \frac{cQ}{l} \qquad (15)$$

where

c = unit cost of a returnable container, \$/container

Q = quantity of container consumed at customer, containers/day

l = container life, years

The term $(R_r^{-1} - 1)$ represents extra days of cycle time caused by decreasing the return ratio. If, for example, the return ratio decreased from one to one to one to four, the three extra days would be added to the total cycle time: $3 = \frac{1}{4}^{-1} - 1$. As the additional containers becomes a part of the container fleet being used over the container life, C_c is the one-time cost that should be amortized over the container life l.

The total cost $C_t(R_r)$ is the sum of $C_t(R_r)$ and $C_c(R_r)$:

$$C_T(R_r) = C_t(R_r) + C_c(R_r) = aT - aTR_r + bTR_r + \frac{cQ}{l}R_r^{-1} - \frac{cQ}{l} \qquad (16)$$

In order to get the optimal return ratio, while balancing additional container cost and transportation cost, C_T was differentiated with respect to R_r:

$$\frac{dC_T(R_r)}{dR_r} = \frac{dC_t(R_r)}{dR_r} + \frac{dC_c(R_r)}{dR_r} = -aT + bT - \frac{cQ}{l}R_r^{-2} = 0 \qquad (17)$$

The derivative was then set to zero and solved for the optimal return ratio $R_r = \sqrt{\frac{cQ}{(b-a)Tl}}$. Assuming *a*, *b*, *c*, and *l* are rate constant, the two major determinants for an optimal return ratio are daily container consumption Q and total number of trips *T* during the container lifetime *l*. As the Q increases, the optimal return ratio increases. As the *T* increases, the optimal return ratio decreases.

COST SIMULATION

In order to examine the paper's basic research questions, two different methods were proposed. First, by changing the key variables one by one, it can be observed that how the individual variable affects the total cost. The six variables found to be important are:

1. Cycle time
2. Average daily usage
3. Pack quantity
4. Delivery distance
5. Peak volume factor
6. Container unit cost (returnable and expendable)

The limitation with this method is that it cannot capture the magnitude of impact by the multiple variables at once.

The cost simulation was designed to capture the possible manufacturing and logistics conditions under which the returnable container systems can be justified. To be more specific, the two sets of cost models, one set of models representing the total cost of expendable container systems and another representing the total cost of returnable container systems, were compared under the various settings of manufacturing and logistics system.

The collection of these settings under which returnable systems are the least expensive can be expressed as a relevant range for using returnable container systems.

In order to generate the various system settings, a spreadsheet static simulation method was developed using Microsoft Excel. Each variable was given three values representing the ranges of systems settings (low, mid, high) (see table 4).

Table 4 An Example of Variables and Ranges

	Variable 1	Variable 2	Variable 3
Low	1	4	7
Mid	2	5	8
High	3	6	9

Assuming that there are m variables, each will be tested at n levels. The total number of test combinations will be n^m. The simulations in this example perform cost analysis with the three variables at the three different levels. Thus, the simulation tested the total of twenty-seven combinations: $27 = 3^3$. The container system cost for each container option can be calculated and compared at each combination (see Table 5). The collection of combinations in favor of returnable container system is shown as the manufacturing and logistics profile limitations to each variable.

Table 5 An Example of Cost Simulation Using Variables and Ranges in Table 4

Seq. No.	Variable 1	Variable 2	Variable 3	Ret. System Cost	Exp System Cost	Difference (Ret-Exp)
1	1	4	7	-	-	-
2	1	4	8	-	-	-
3	1	4	9	-	-	-
4	1	5	7	-	-	-
5	1	5	8	-	-	-
6	1	5	9	-	-	-
7	1	6	7	-	-	-
8	1	6	8	-	-	-
9	1	6	9	-	-	-
10	2	4	7	-	-	-
11	2	4	8	-	-	-
12	2	4	9	-	-	-
13	2	5	7	-	-	-
14	2	5	8	-	-	-
15	2	5	9	-	-	-
16	2	6	7	-	-	-
17	2	6	8	-	-	-
18	2	6	9	-	-	-
19	3	4	7	-	-	-
20	3	4	8	-	-	-
21	3	4	9	-	-	-
22	3	5	7	-	-	-
23	3	5	8	-	-	-
24	3	5	9	-	-	-
25	3	6	7	-	-	-
26	3	6	8	-	-	-
27	3	6	9	-	-	-

The actual simulation was performed with the five variables at three levels for three different container categories. The total number of combinations tested was $243 = 3^5$ for each container category. The variables and ranges are summa

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summarized in the Table 6. These numbers are selected, based on the results from the individual variable analysis. For the variables with the depleting points, the depleting points was selected as the high value because any point beyond the depleting points wouldn't be much impact on the container systems cost. The variables without depleting points were given numbers for the ranges based on my internship experience and data from literatures.

Table 6 Variables and associated ranges

	CT	ADV	PVF	PQ	DD	CUC	
						Exp	Ret
Low	14	1,000	1.1	10	500	0.5	6
Middle	28	5,000	1.5	50	1,500	3	24
High	42	10,000	2.0	100	3,000	60	400

CT: cycle time, days
ADV: average daily volume, parts/day
PVF: peak volume factor
PQ: pack quantity, parts/container
CUC: container unit cost, $/container
DD: delivery distance, miles

Since the cycle time doesn't have depleting point, the cycle time was given the numbers of 14, 28, 42 days as the range. Although it varies from manufactures to manufactures, the automobile industry practices 14 days of container cycle time which is know as short. The container system costs starts depleting when the average daily volume is around 10,000 parts. The ranges for the average daily volume are 1,000 parts per day as low, 5,000 parts per day as mid, and 10,000 parts per day as high. The container system costs do not have any depleting point for peak volume factor, so the peak volume factor was given numbers of 10, 50, and 100 percent of the average daily volume. Considering various characteristics of products, 100 percent of the average daily volume could be considered as high in the demand fluctuation. The container system cost starts depleting when the pack quantity is around 100 parts per container, so the give

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the given numbers for the range are 10 for low, 50 for mid and 100 for high. Delivery Distance was tested at 500, 1,500, and 3,000 miles. Considering the approximate distance from east coast to west coast is 3,000 miles, the high distance was set to 3,000 miles. The other two values were set based on low and moderate distance moves representing low and mid ranges.

Container unit cost was given ranges of $6 (low), $24 (mid), and $400 (high) for the returnable containers and $0.5 (low), $3 (mid), and $60 (high) for the expendable containers. These are approximate costs for the existing containers that are used in GM Powertrain. The low range containers are based on the container size 15 x 12 x 8 and 48 x 45 pallet. The expendable container is made of single wall corrugated board. The returnable container is injection molded tote. This is one of the standard size containers that doesn't require tooling charges for both expendable and returnable. Mid range containers are based on the 24 x 15 x 18 containers and 48 x 45 pallet. This container is for odd shape and relatively big and heavy part. The expendable containers are made of single wall corrugated with customized inserts for protection and part presentation. The returnable container is customized vacuum formed plastic containers. No separate insert is required since the contour of the containers is designed for the specific product shape. The high container cost is based on 48 x 45 x 45 steel rack for returnable container and same size corrugated container with wood supports for expendable container. This container holds heavy parts.

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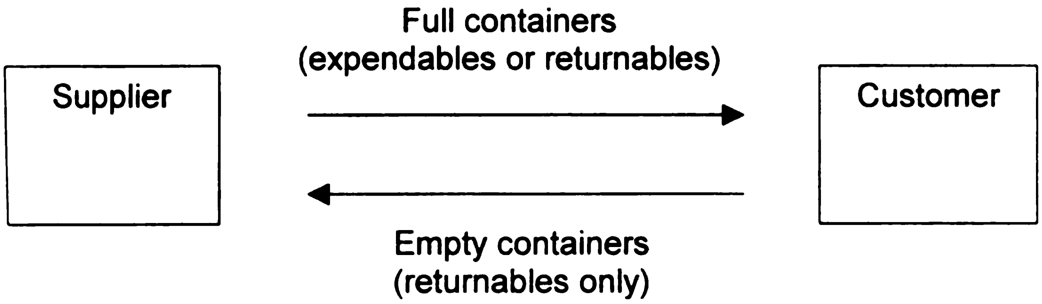
The container unit costs vary in terms of its size, material used, complexity of design, etc. Container cost also varies among the container manufacturers. However, it should be able to capture the impact of container unit cost.

Model Description

Figure 3 depicts the basic supply chain configuration (fixed variables) that was utilized in the both container cost simulations. As illustrated in the figure, it was assumed that a supplier serves a manufacturing facility (customer) for a single part. The line represents the transportation link that moves containers from supplier to customer. In the expendable container system model, the flow of containers is one-way, so no empty containers are going back to supplier. In the returnable container system model, the flow of containers is two-way, and the empty containers are going back to the supplier.

Figure 3 Simulated Distribution Configurations



The transportation from supplier to customer is scheduled once every day for both models. The trucks take the empties back to supplier after unloading full containers. The amount of empty containers going back to supplier is supposed to be the same as what is came into customers (one-to-one return ratio). In reality, however, containers get damaged, stolen, etc. It is assumed that it is necess

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necessary to purchase the additional 10% of the initial container quantities for the next two years.

Two other assumptions associated with the transportation system are the difference of cubic efficiency and weight factors. The cubic efficiency and weight related rate between the two container systems are assumed to be same.

The simulation calculates the returnable container systems cost based on 2-year return on investment, so the container life is fixed at 2 years. Returnable containers, in general, last longer than 2 years. The container life represents two possibilities. First, regardless of amount of investment, a customer cannot tolerate any investment that can't pay back within two years. Second, although the actual container life is longer than 2 years, it is assumed that the product life will be supplied for only 2 years. For example, GM Powertrain implements returnable container system only if 2-year return on investment is possible, and some of the parts become obsolete as new model comes out every year.

Labor cost calculation is based on the information in table 7. The information is based on GM Powertrain Engine Plant during my internship in 1999, and captures the major activities involved in the both container systems. The model does not include any activities at the supplier assuming that suppliers' labor costs are the same for both packaging systems.

Table 7 Labor time involved in the two container systems

Seq. No.	Expendable	Returnable
1	Load box to tugger	Load tote to tugger
2	Cut open box (300~400 sq. in. top per box)	Unload tote to creform/load empty to tugger
3	Dispose box tops (estimated per box)	Place empty tote to dunnage sort area (estimate**)

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4	Unload box to creform/load empty to tugger	Load tote to truck (per pallet estimate***)
5	Dispose empty box in gondola (per 4 boxes)	
6	Empty gondola (per gondola*)	
	Total: 0.65 min per container	Total: 0.38 min per container
* Assume 50 empty boxes per gondola ** Assume (4) totes at a time brought from tugger to sort area *** Assume: 32 empty totes/pallet and 500' round trip from/to tote storage to dock		

Table 7 represents the time taken for the set of activities involved in the both packaging systems. For expendable containers, it is loaded to a tugger. The tugger is a delivery vehicle routing between the storage area and production line (workstations). As loading the containers to tugger, the container tops are cut open. The box tops are disposed. The containers are delivered to the proper workstations. Each workstation has a creform (gravity rack) where at least two-hours inventory should be available for an assembler all the time. As loading containers to the creforms, pick up empties and dispose them in gondola. The gondola is emptied on the regular basis depends on the filling rates. The estimated time consumption for expendable container system is 0.65 min per container.

For returnable containers, it is loaded to tugger. The returnable containers do not require cutting tops. The containers are delivered to the designated workstations and unloaded to creform. After unloading full containers, empties are loaded to tugger. The tugger driver places empty containers to sorting area. The empties, then, staged and loaded to truck going back to the supplier. The estimated time for this set of activities is 0.38 min per container.

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Disposal cost for expendable container system is based on a fixed container weight for each classification. Low cost containers are assumed to be 3 pounds. Mid cost containers are to be 5 pounds and 50 pounds for high cost containers. This weight should include any fraction weight of pallet, label, and any other shipping material. There is no logic or data behind this numbers. It is just to make a distinction between the classes. The disposal rate for recycling is $0.0475 per pound (National Solid Waste Management Association 1992).

Data Evaluation

Multiple regression analysis was used to evaluate the result data from the multi-variable cost simulation in order to estimate the relationship between the independent variables (X_1) and the dependent variable (Y). In this study, the independent variables are the five cost drivers and the dependent variable is the difference between the returnable container systems' cost and expendable systems' cost. For each dependent variable, the technique of least-squares was used to estimate the regression coefficients (b_i) in an equation of the form:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n + u$$

where u denotes a random disturbance term. The regression coefficient (b_i) represents the expected change in the performance indicator associated with a one-unit change in the ith independent variable.

The coefficients (b_i) depend upon the units of measurement for Y and X_i. Using the standardized independent variables (X_i'), the regression coefficients (b_i) do not depend upon the units of measurement and facilitate a comparison of the relative impact of different variables. The standardized independent variab

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variables (X_i') can then be interpreted as the number of standard deviations that Y is expected to change in response to a one standard deviation change in X_i'.

The standardized variables from Table 6 are presented in the Table 8.

Table 8 Standardized Variables and associated ranges

	CT	ADV	PVF	PQ	DD	CUC
Low	-1	-0.96	-0.96	-0.96	-0.93	-0.64
Middle	0	-0.07	-0.07	-0.07	-0.13	-0.54
High	1	1.04	1.04	1.04	1.06	1.15

CT: cycle time
ADV: average daily volume
PVF: peak volume factor
PQ: pack quantity
CUC: container unit cost
DD: delivery distance

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CHAPTER 4

RESULTS

This section provides a discussion of the cost comparisons between the expendable and the returnable container system models for various manufacturing and logistics settings and the optimal return ratio for collapsible/nestable returnable containers. First, discussion addresses the impact of individual variable to the total container system cost. Second, the optimal return ratio is discussed. Third, the results from the multi-variable cost simulation are discussed using findings from the multiple regression analysis and the manufacturing and logistics profile.

SINGLE VARIABLE ANALYSIS

Cycle Time (CT)

The returnable container system cost increases in proportion to the cycle time (see Figure 4). The specific parameters associated with the Figure 4 are presented in Table 9. As cycle time increases from 7 to 34 days, the increase in container system cost was from $0.4182 to $0.4645 (about $ 0.05) per part. As the cycle time increases, the total returnable container system cost increases because more containers are required.

The magnitude of the impact by the cycle time is relatively low. The increase in the cycle time increases the container initial investment. However, the ad

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the additional container cost for the increased cycle time is not significant after the cost is amortized over the container life.

The same cost prediction was performed with mid and high cost containers. Figure 5 and Table 10 represent the cost prediction results for mid cost container set, and Figure 6 and Table 11 for high cost container set. In case of low cost containers, a returnable container system could not be justified with any cycle time between 7 and 34. However, savings became possible up to about 30 days of cycle time for mid cost containers, and all cycle times for high cost containers. As the container unit cost increases, the cycle can be longer for the returnable container system to be justified.

Figure 4 Impact of Cycle Time for Low Cost Container Set

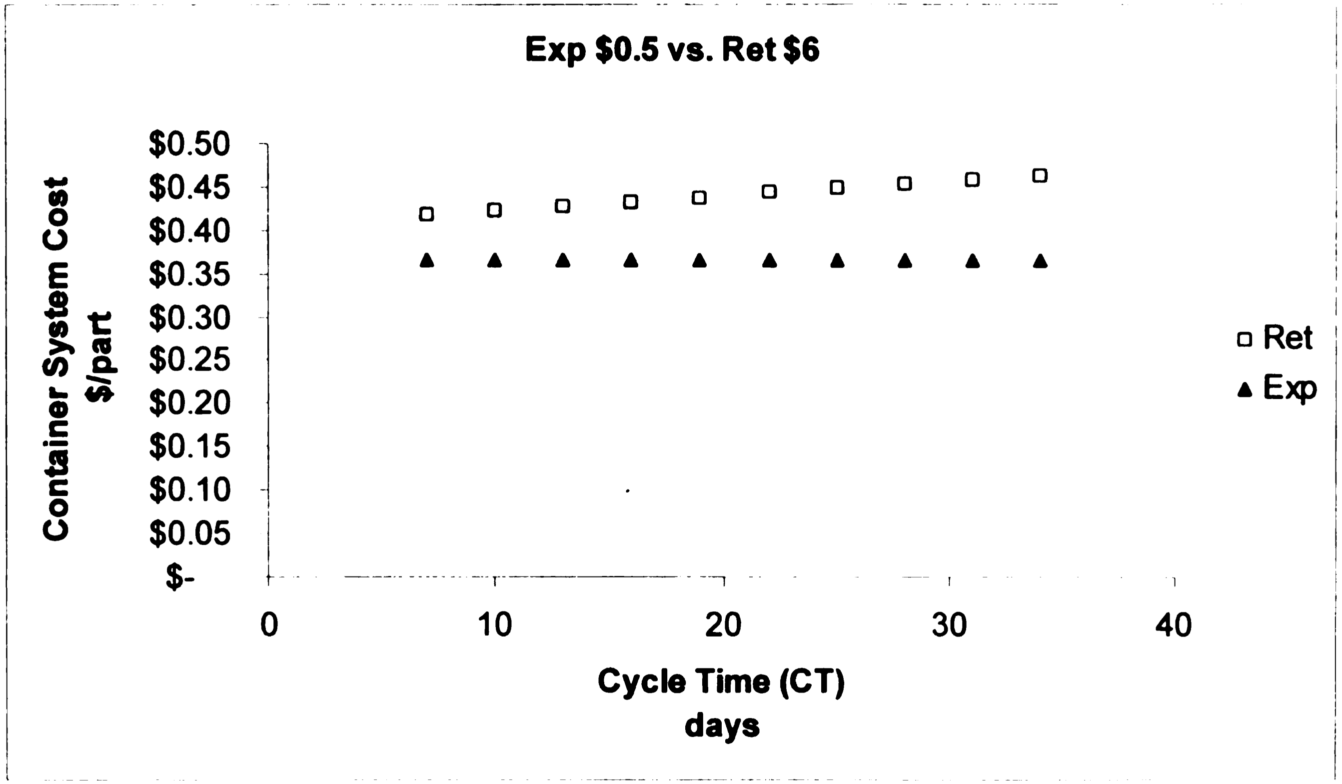

Table 9 Impact of Cycle Time for Low Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$6.00	**7**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4182**	**$0.37**
$6.00	**10**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4234**	**$0.37**
$6.00	**13**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4285**	**$0.37**
$6.00	**16**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4337**	**$0.37**
$6.00	**19**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4388**	**$0.37**
$6.00	**22**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4440**	**$0.37**
$6.00	**25**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4491**	**$0.37**
$6.00	**28**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4542**	**$0.37**
$6.00	**31**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4594**	**$0.37**
$6.00	**34**	1.3	10	1.	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4645**	**$0.37**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 5 Impact of Cycle Time for Mid Cost Container Set

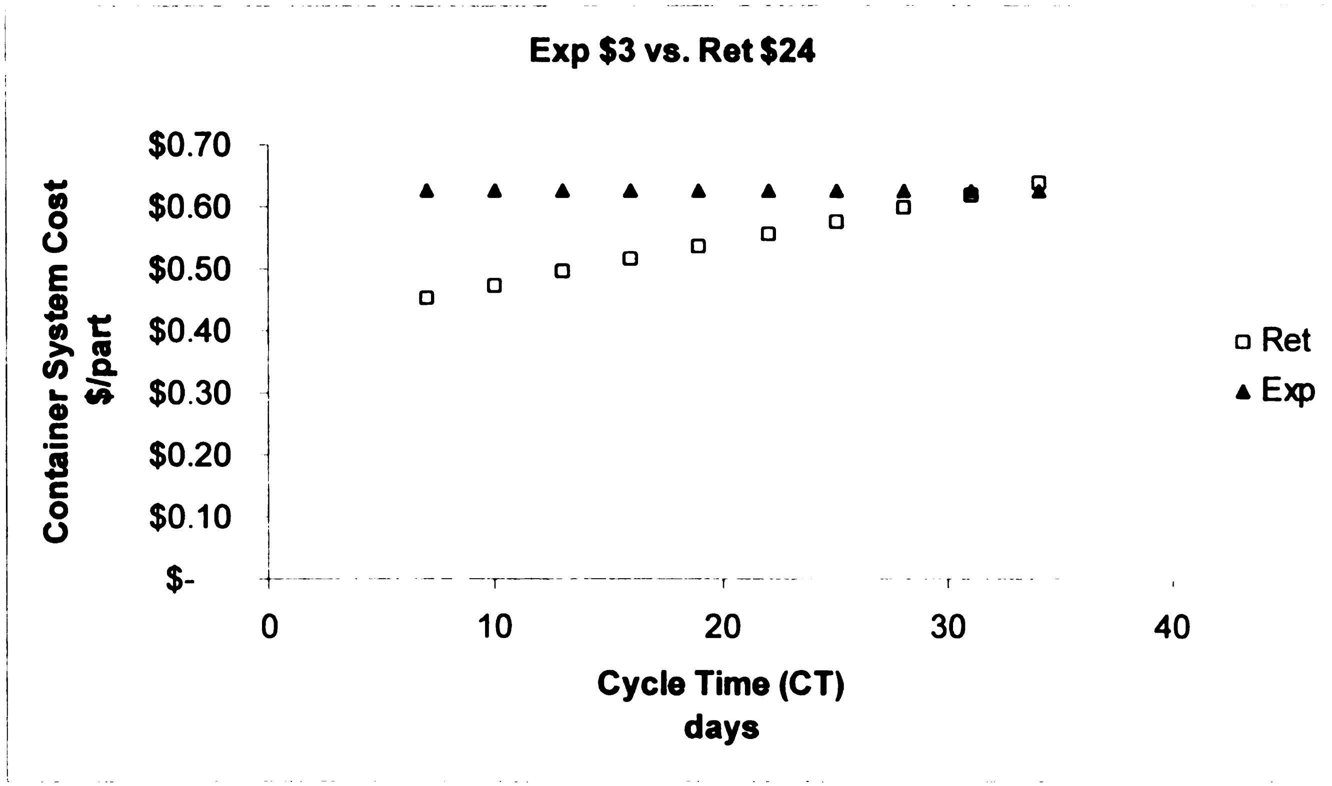

Table 10 Impact of Cycle Time for Mid Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$24.00	**7**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.45**	**$0.63**
$24.00	**10**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.47**	**$0.63**
$24.00	**13**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.50**	**$0.63**
$24.00	**16**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.52**	**$0.63**
$24.00	**19**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.54**	**$0.63**
$24.00	**22**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.56**	**$0.63**
$24.00	**25**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.58**	**$0.63**
$24.00	**28**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.60**	**$0.63**
$24.00	**31**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.62**	**$0.63**
$24.00	**34**	1.3	10	1.1	2	3000	600	1.41	1	0.38	1	**$3.00**	0.65	5	0.0475	**$0.64**	**$0.63**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 6 Impact of Cycle Time for High Cost Container Set

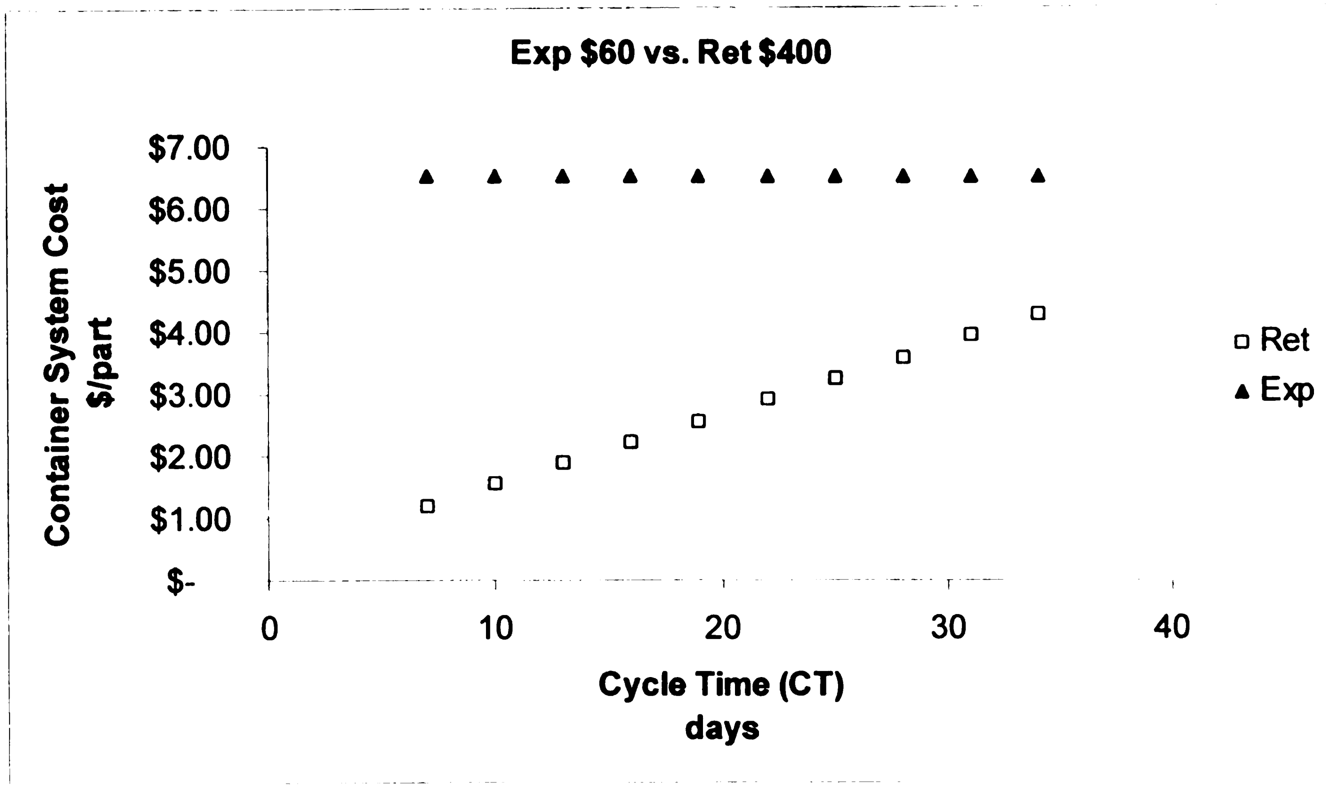

Table 11 Impact of Cycle Time for High Cost Container Set

UCR	**CT**	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$400.00	**7**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.21**	**$6.54**
$400.00	**10**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.55**	**$6.54**
$400.00	**13**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.89**	**$6.54**
$400.00	**16**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.24**	**$6.54**
$400.00	**19**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.58**	**$6.54**
$400.00	**22**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.92**	**$6.54**
$400.00	**25**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$3.27**	**$6.54**
$400.00	**28**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$3.61**	**$6.54**
$400.00	**31**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$3.95**	**$6.54**
$400.00	**34**	1.3	10	1.1	2	3000	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$4.30**	**$6.54**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Average Daily Volume (ADV)

Increasing the average daily volume reduces costs for both kinds of container systems. Figure 7 and Table 12 show the results of the low cost container set in comparison of expendable and returnable container system cost. As the average daily volume was increased from 1,000 to 10,000 parts, the returnable container system cost decreased from $1.20 to $0.13 per part, and the expendable container system cost decreased from $0.93 to $0.17 per part. The interesting observation is that the cost of returnable container system decreases at a faster rate than expendable container system.

As the container cost increases, the decreasing rate increases. Figure 8 and Table 13 show the results for cost prediction for mid cost set, and the Figure 9 and Table 14 show the results for cost prediction. The savings become possible when the average daily volume was greater than 6,000 parts per day for the low cost container set, 2,000 parts per day for the mid cost container set, and any daily volumes for the high cost container set.

The economies of scale are the reason for this behavior. The sensitivity of economies of scale is greater with the returnable container systems because the returnable container unit cost is higher than expendable container unit cost. In other words, when the higher container cost diminishes over the large amount of the daily volume, it does faster than the lower container cost. For example, if 2 divide a number 20, it becomes 10. If a number 40 divided by 2, it becomes 20. The number decreased by 10 in the first case, and by 20 in the second case. It is clearly shown that the decreasing rate is faster for the higher number. In addition, the expendable container cost is expense, but the returnable container cost diminishes over number of trips between the supplier and customer for the given period of time. Returnable container system cost can be more easily justified with higher daily volume and higher cost containers.

Figure 7 Impact of Average Daily Volume for Low Cost Container Set

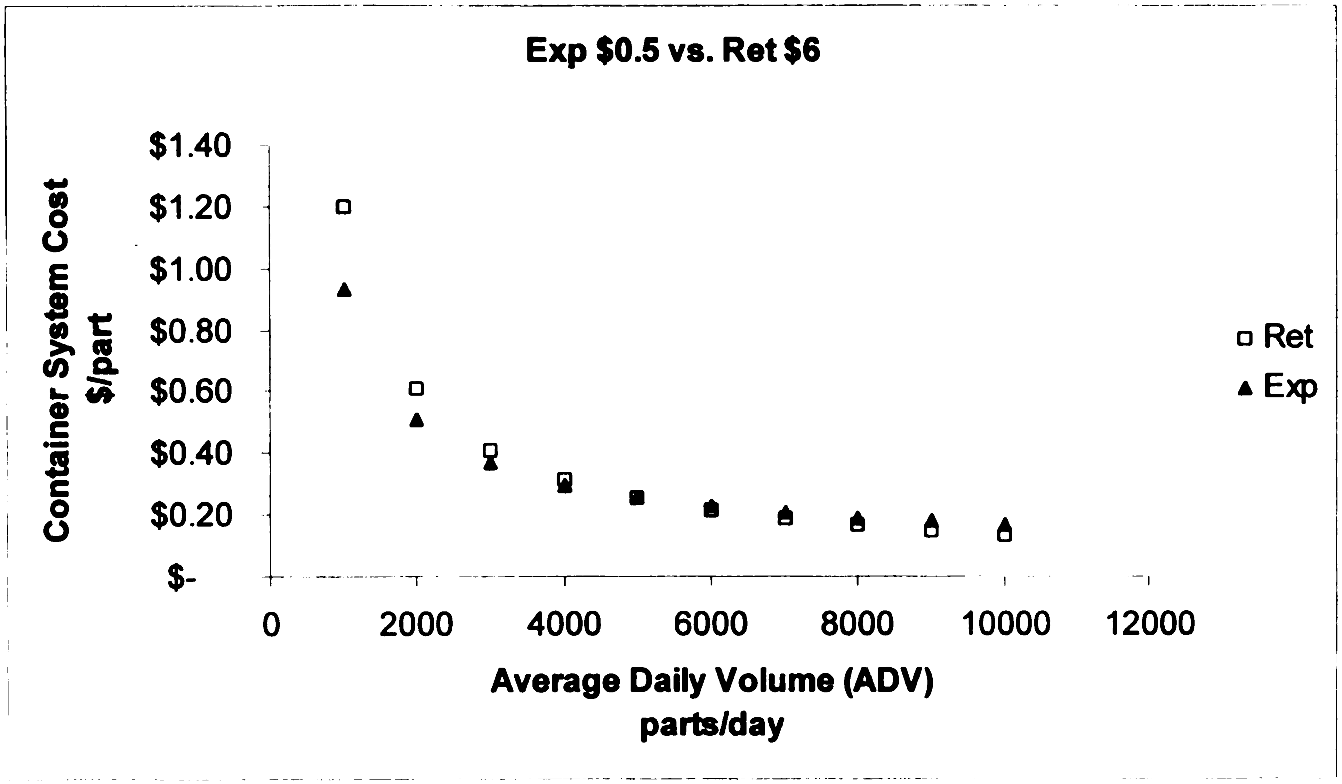

Table 12 Impact of Average Daily Usage for Low Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$6.00	3	1.3	10	1.	2	**1000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.20**	**$0.93**
$6.00	3	1.3	10	1.	2	**2000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.61**	**$0.51**
$6.00	3	1.3	10	1.	2	**3000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.41**	**$0.37**
$6.00	3	1.3	10	1.	2	**4000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.31**	**$0.30**
$6.00	3	1.3	10	1.	2	**5000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.25**	**$0.25**
$6.00	3	1.3	10	1.	2	**6000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.21**	**$0.22**
$6.00	3	1.3	10	1.	2	**7000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.19**	**$0.20**
$6.00	3	1.3	10	1.	2	**8000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.16**	**$0.19**
$6.00	3	1.3	10	1.	2	**9000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.15**	**$0.18**
$6.00	3	1.3	10	1.	2	**10000**	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.13**	**$0.17**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 8 Impact of Average Daily Volume for Mid Cost Container Set

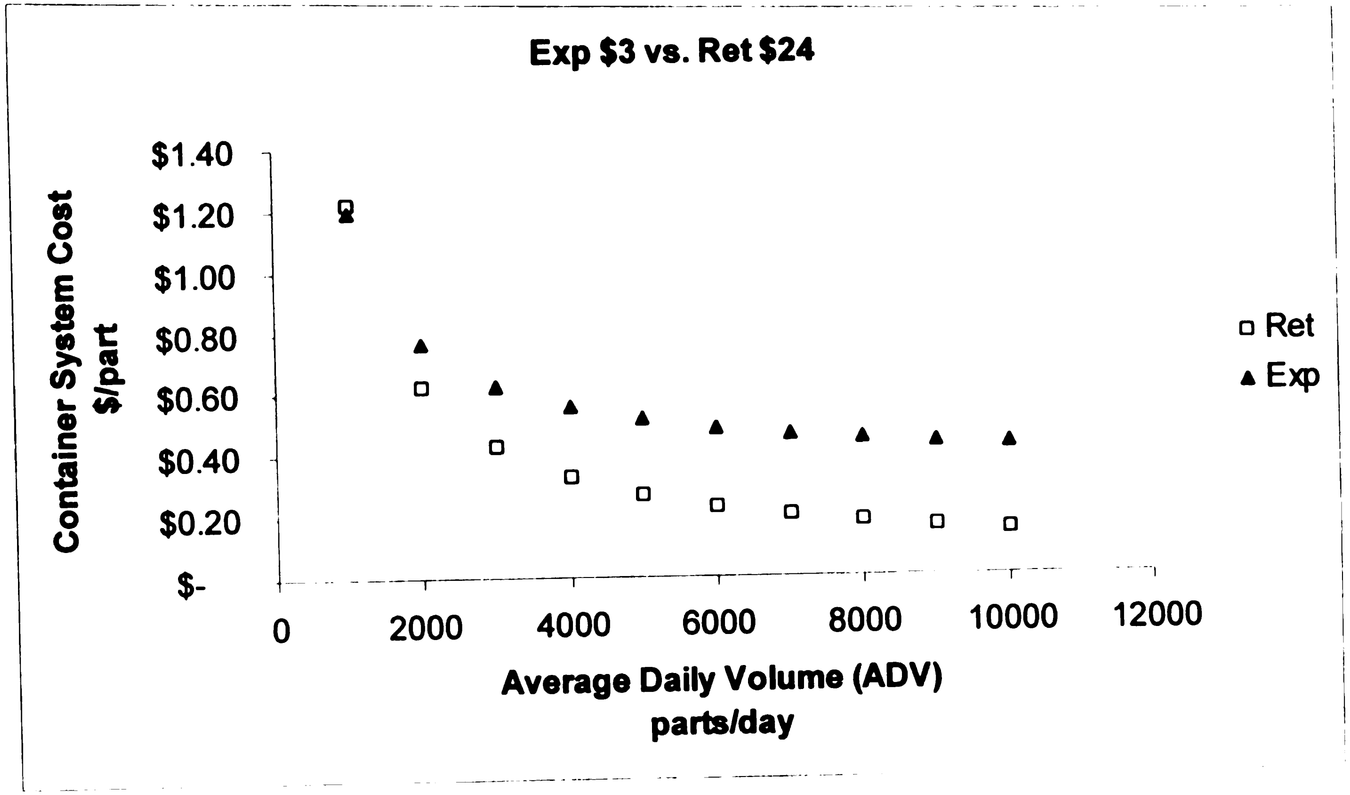

Table 13 Impact of Average Daily Usage for Mid Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$24.00	3	1.3	10	1.1	2	**1000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.22**	**$1.19**
$24.00	3	1.3	10	1.1	2	**2000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.62**	**$0.77**
$24.00	3	1.3	10	1.1	2	**3000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.43**	**$0.63**
$24.00	3	1.3	10	1.1	2	**4000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.33**	**$0.55**
$24.00	3	1.3	10	1.1	2	**5000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.27**	**$0.51**
$24.00	3	1.3	10	1.1	2	**6000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.23**	**$0.48**
$24.00	3	1.3	10	1.1	2	**7000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.20**	**$0.46**
$24.00	3	1.3	10	1.1	2	**8000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.18**	**$0.45**
$24.00	3	1.3	10	1.1	2	**9000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.16**	**$0.44**
$24.00	3	1.3	10	1.1	2	**10000**	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.15**	**$0.43**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 9 Impact of Average Daily Volume for High Cost Container Set

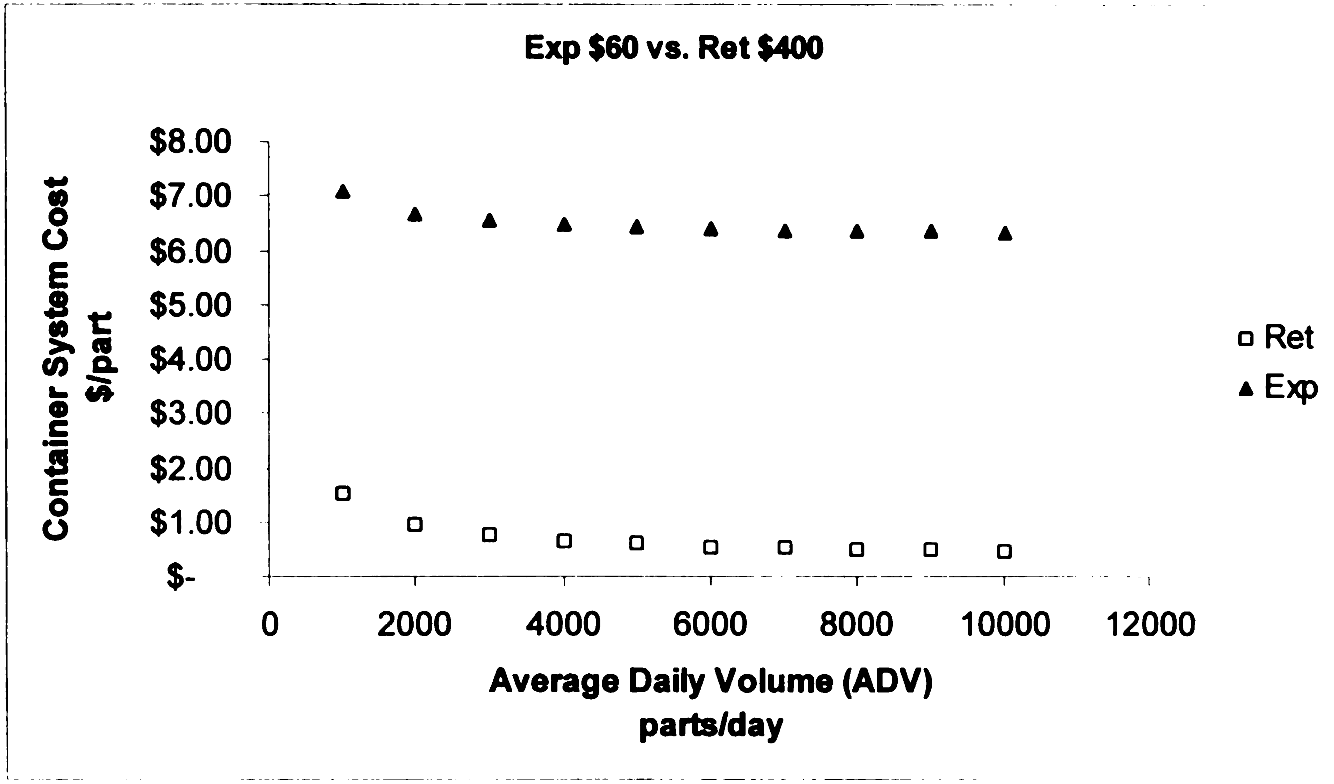

Table 14 Impact of Average Daily Usage for High Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$400.00	3	1.3	10	1.1	2	**1000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.54**	**$7.10**
$400.00	3	1.3	10	1.1	2	**2000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.95**	**$6.68**
$400.00	3	1.3	10	1.1	2	**3000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.75**	**$6.54**
$400.00	3	1.3	10	1.1	2	**4000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.65**	**$6.47**
$400.00	3	1.3	10	1.1	2	**5000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.59**	**$6.43**
$400.00	3	1.3	10	1.1	2	**6000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.55**	**$6.40**
$400.00	3	1.3	10	1.1	2	**7000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.52**	**$6.38**
$400.00	3	1.3	10	1.1	2	**8000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.50**	**$6.36**
$400.00	3	1.3	10	1.1	2	**9000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.49**	**$6.35**
$400.00	3	1.3	10	1.1	2	**10000**	60	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.47**	**$6.34**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Peak Volume Factor (PVF)

Recall that the peak volume factor (PVF) is a measure of the fluctuations in the average daily volume (ADV). The impact of fluctuations for the low cost container set was observed for the peak volume increasing from 10 % to 100 %. As the peak volume factor was increased, the returnable system cost increased very little, from $0.4106 to $0.4141 per part (see Figure 10 and Table 15).

High fluctuations did affect the container system cost. However, the impact is relatively low. Increasing the peak volume factor actually increases the average daily volume, 3,000 parts per day in this case. The increase from 10% to 100% was actually the increase of average daily volume from 3,100 to 6,000. The impact of average daily volume was relatively high in the previous section. The increase in the average daily volume (ADV) increases the annual volume that causes the significant increase in the initial investment.

However, unlike average daily volume (ADV) in the previous section, this increase by peak volume factor is not related to annual volume (see equation for returnable container system cost). The peak volume factor only measures the cost impact of additional containers for the daily fluctuation. The additional containers cost for daily fluctuation become significantly low after the cost amortized by number of usages over containers' life.

Higher container cost overcomes the effect of peak volume factor significantly as it did for the other variables. Figure 11 and Table 16 present the results for mid cost container set, and Figure 12 and Table 17 present the results for high cost container set. With the higher cost containers, the peak volume factor does not affect the overall system's cost.

Figure 10 Impact of Peak Volume Factor for Low Cost Container Set

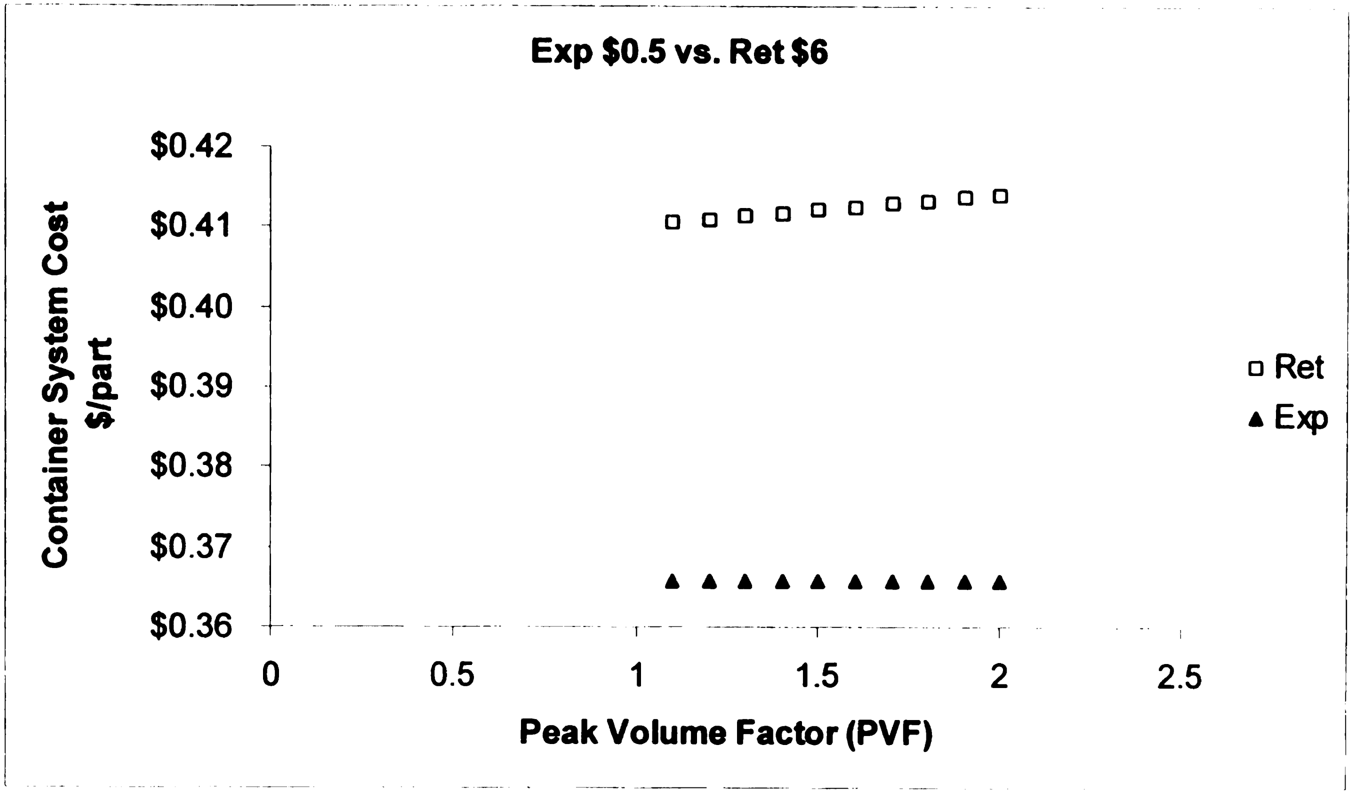

Table 15 Impact of Peak Volume Factor for Low Cost Container Set

UCR	CT	**PVF**	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$6.00	3	**1.1**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4106**	**$0.37**
$6.00	3	**1.2**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4110**	**$0.37**
$6.00	3	**1.3**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4113**	**$0.37**
$6.00	3	**1.4**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4117**	**$0.37**
$6.00	3	**1.5**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4121**	**$0.37**
$6.00	3	**1.6**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4125**	**$0.37**
$6.00	3	**1.7**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4129**	**$0.37**
$6.00	3	**1.8**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4133**	**$0.37**
$6.00	3	**1.9**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4137**	**$0.37**
$6.00	3	**2**	10	1.1	2	3000	600	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.4141**	**$0.37**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 11 Impact of Peak Volume Factor for Mid Cost Container Set

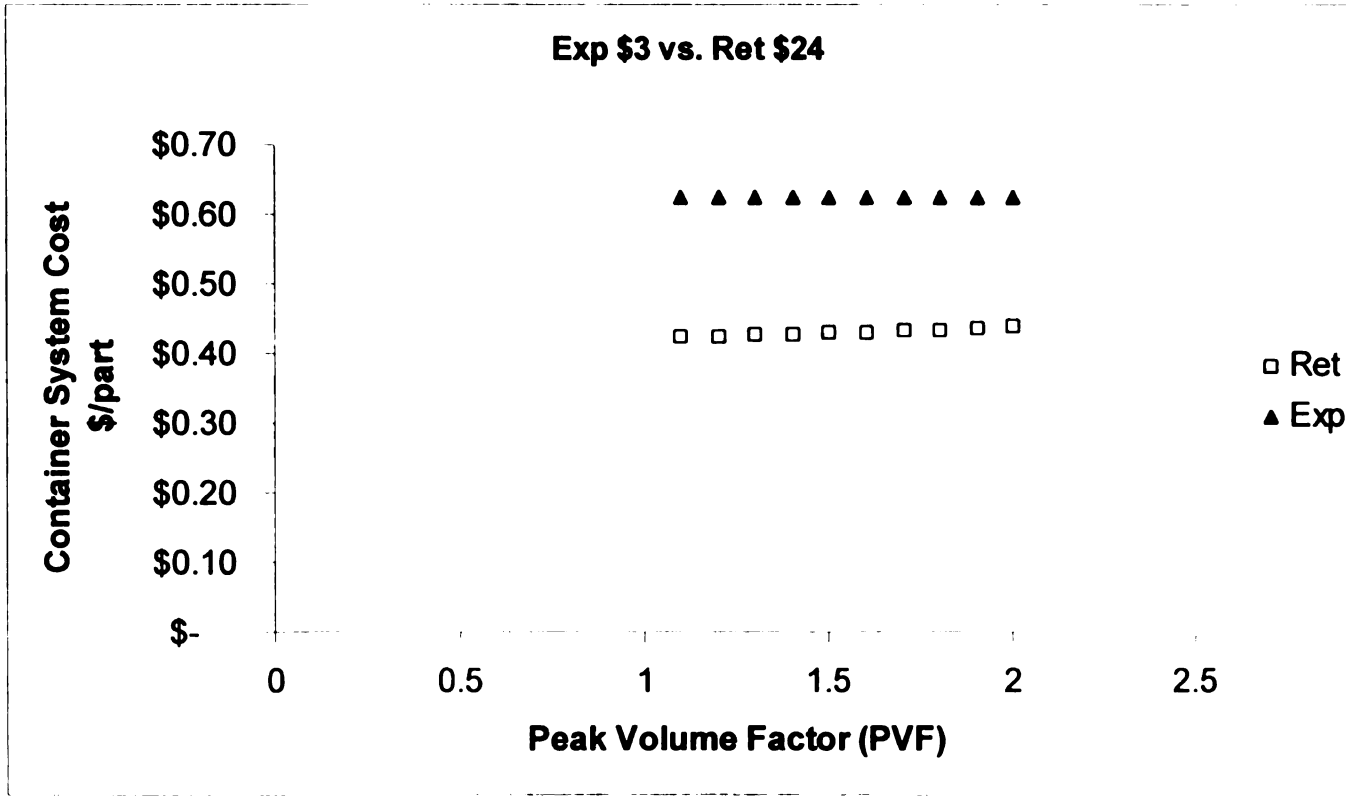

Table 16 Impact of Peak Volume Factor for Mid Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$24.00	3	**1.1**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4236**	**$0.63**
$24.00	3	**1.2**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4252**	**$0.63**
$24.00	3	**1.3**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4268**	**$0.63**
$24.00	3	**1.4**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4284**	**$0.63**
$24.00	3	**1.5**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4300**	**$0.63**
$24.00	3	**1.6**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4315**	**$0.63**
$24.00	3	**1.7**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4331**	**$0.63**
$24.00	3	**1.8**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4347**	**$0.63**
$24.00	3	**1.9**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4363**	**$0.63**
$24.00	3	**2**	10	1.1	2	300	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4379**	**$0.63**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 12 Impact of Peak Volume Factor for High Cost Container Set

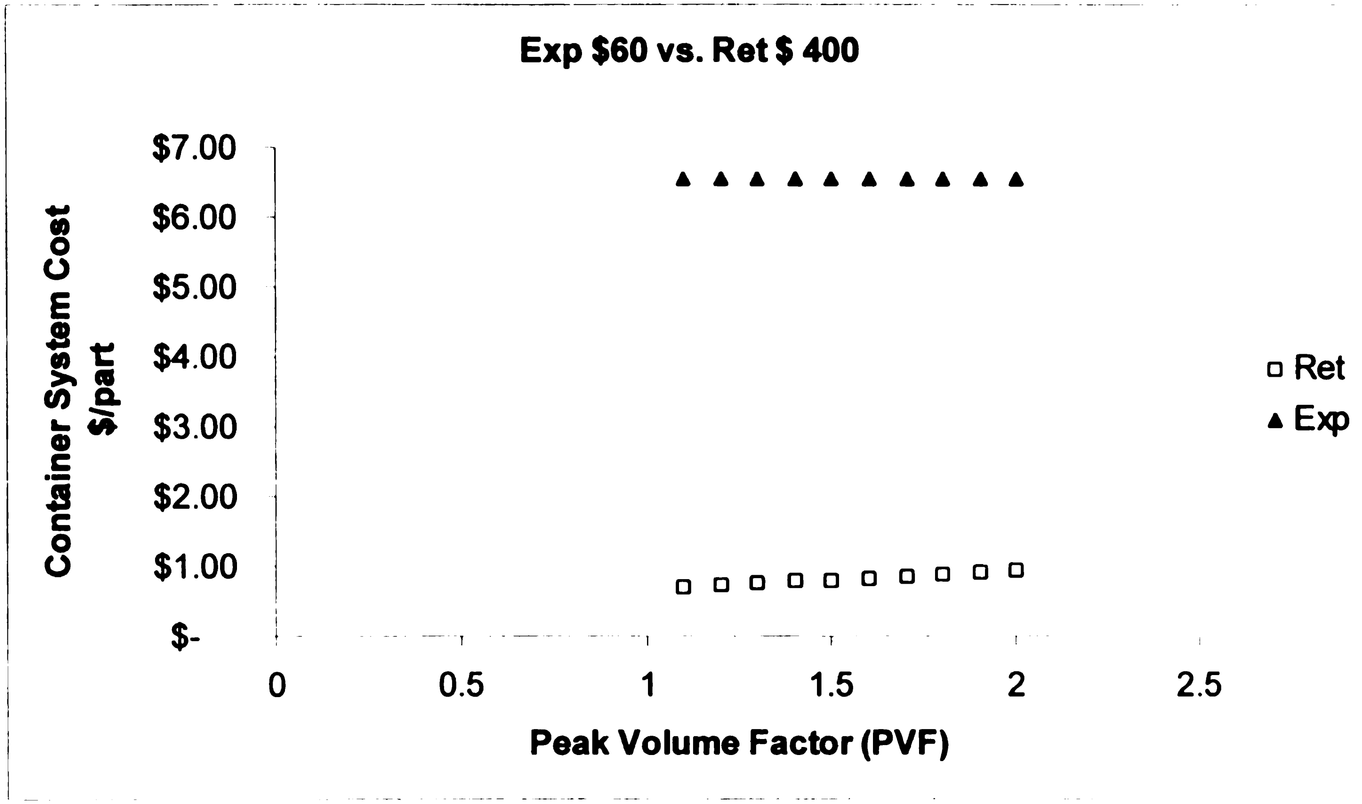

Table 17 Impact of Peak Volume Factor for High Cost Container Set

UCR	CT	**PVF**	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$400.00	3	**1.1**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.70**	**$6.54**
$400.00	3	**1.2**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.72**	**$6.54**
$400.00	3	**1.3**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.75**	**$6.54**
$400.00	3	**1.4**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.78**	**$6.54**
$400.00	3	**1.5**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.80**	**$6.54**
$400.00	3	**1.6**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.83**	**$6.54**
$400.00	3	**1.7**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.86**	**$6.54**
$400.00	3	**1.8**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.88**	**$6.54**
$400.00	3	**1.9**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.91**	**$6.54**
$400.00	3	**2**	1	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.93**	**$6.54**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Pack Quantity (PQ)

The pack quantity was varied from 10 to 560 parts per container. The results for the low cost container set are shown in Figure 13 and Table 18. As the pack quantity increased, the cost decreased from $0.4113 to $0.3951 per part for the returnable container system and from $0.3658 to $0.2835 per part for the expendable container system.

Returnable container systems can be more easily justified with lower pack quantity. Economies of scale can explain this behavior. The increase in pack quantity is spread over the fixed container investment, labor cost, and disposal cost. The reason that the returnable container system cost is less sensitive is that since the container unit cost is already amortized over its lifetime, the pack quantity does not impact as mush as on the expendable container systems.

With higher container unit cost, the savings can be achieved more easily. The returnable container systems could not be justified for the low cost container set. As the container cost increased to the mid and high cost container set, the economic justification became possible. For the mid cost container set, savings was possible up to 20 parts per container (see Figure 14 and Table 19). For the high cost container set, the savings was available up to 480 parts per container, and the savings was greater than the mid cost container set (see Figure 15 and Table 20).

Figure 13 Impact of Pack Quantity for Low Cost Container Set

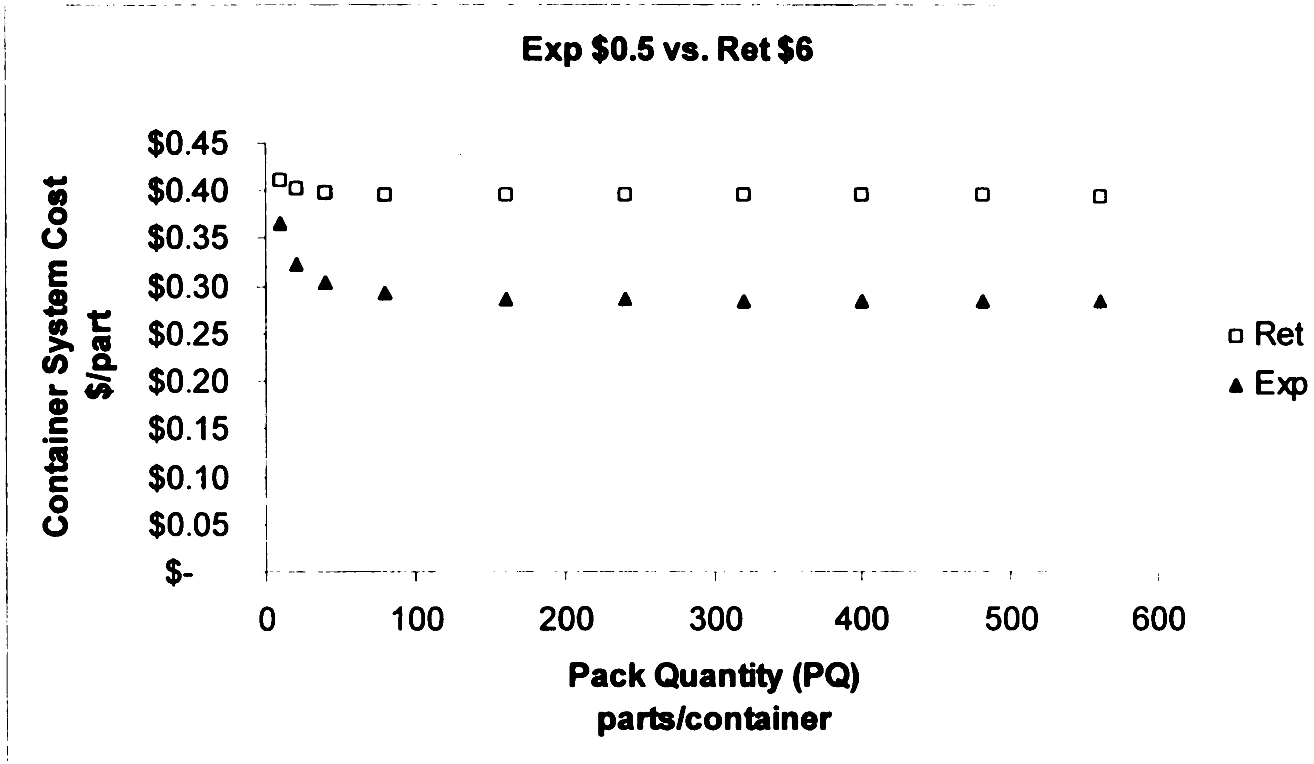

Table 18 Impact of Pack Quantity for Low Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$6.00	3	1.3	**10**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.4113**	**$0.3658**
$6.00	3	1.3	**20**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.4031**	**$0.3239**
$6.00	3	1.3	**40**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3989**	**$0.3029**
$6.00	3	1.3	**80**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3969**	**$0.2925**
$6.00	3	1.3	**160**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3958**	**$0.2872**
$6.00	3	1.3	**240**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3955**	**$0.2855**
$6.00	3	1.3	**320**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3953**	**$0.2846**
$6.00	3	1.3	**400**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3952**	**$0.2841**
$6.00	3	1.3	**480**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3951**	**$0.2837**
$6.00	3	1.3	**560**	1.1	2	3000	60	1.41	1	0.38	18	**$0.50**	0.65		0.0475	**$0.3951**	**$0.2835**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 14 Impact of Pack Quantity for Mid Cost Container Set

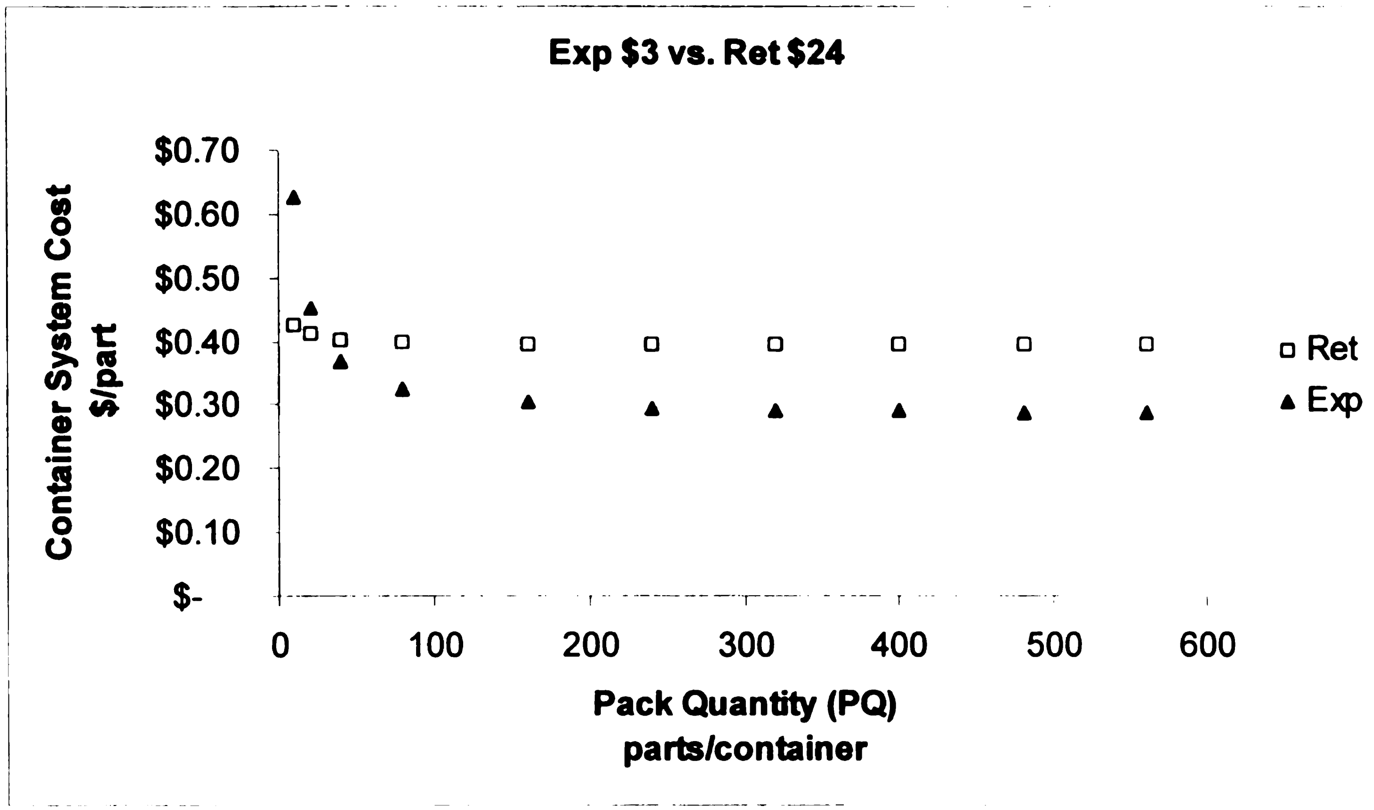

Table 19 Impact of Pack Quantity for Mid Cost Container Set

UCR	CT	PVF	**PQ**	CRR	CL	ADV	DD	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$24.00	3	1.3	**10**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4268**	**$0.6253**
$24.00	3	1.3	**20**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4108**	**$0.4536**
$24.00	3	1.3	**40**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.4028**	**$0.3678**
$24.00	3	1.3	**80**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3988**	**$0.3249**
$24.00	3	1.3	**160**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3968**	**$0.3035**
$24.00	3	1.3	**240**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3961**	**$0.2963**
$24.00	3	1.3	**320**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3958**	**$0.2927**
$24.00	3	1.3	**400**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3956**	**$0.2906**
$24.00	3	1.3	**480**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3955**	**$0.2892**
$24.00	3	1.3	**560**	1.1	2	3000	600	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.3954**	**$0.2881**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 15 Impact of Pack Quantity for High Cost Container Set

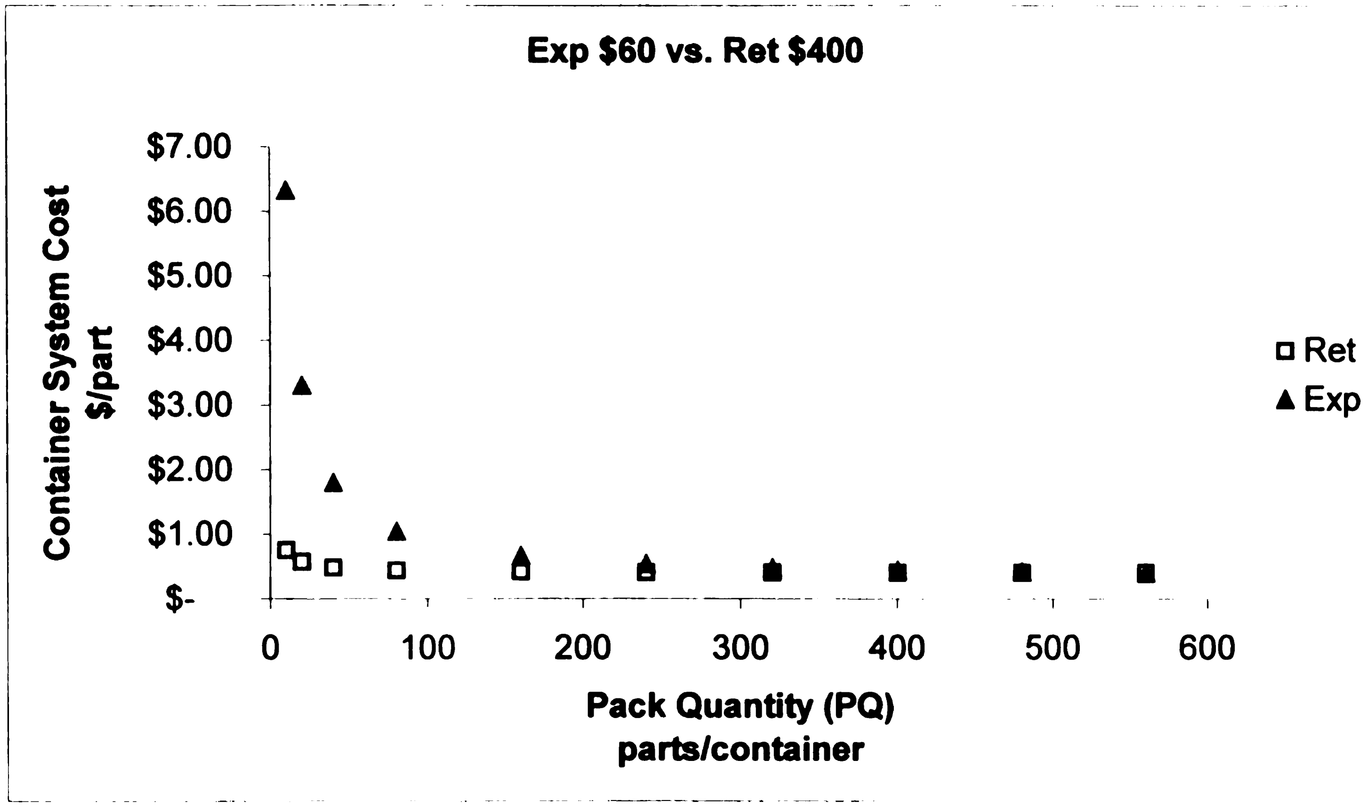

Table 20 Impact of Pack Quantity for High Cost Container Set

UCR	CT	PVF	**PQ**	CRR	CL	ADV	DD	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$400.00	3	1.3	**10**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.7494**	**$6.54**
$400.00	3	1.3	**20**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.5721**	**$3.41**
$400.00	3	1.3	**40**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4835**	**$1.85**
$400.00	3	1.3	**80**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4391**	**$1.06**
$400.00	3	1.3	**160**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4170**	**$0.67**
$400.00	3	1.3	**240**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4096**	**$0.54**
$400.00	3	1.3	**320**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4059**	**$0.48**
$400.00	3	1.3	**400**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4037**	**$0.44**
$400.00	3	1.3	**480**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4022**	**$0.41**
$400.00	3	1.3	**560**	1.1	2	300	600	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.4011**	**$0.39**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Delivery Distance (DD)

The delivery distance was varied from 500 to 3,200 miles. The response to the increase in the delivery distance was to increase the both container systems' costs. This increase is due to the increase in the transportation cost by the increased delivery distance. The results are shown in Figure 16 and Table 21 for the low cost container set, in Figure 17 and Table 22 for the mid cost container set, and in Figure 18 and Table 23 for the high cost set.

For the low cost container set, no savings was available for the returnable container system at any distance. The returnable container system cost for the low cost container increased from $0.35 for short distance to $2.12 per part for long distance, and from $0.32 to $1.59 per part for expendable container system. However, savings can be expected if the cost prediction was projected to the lower than 500 mile. It is more likely that the returnable container system can be justified with the higher cost containers. The mid cost returnable containers were cost effective up to 1400 miles. High cost containers were cost justified all the way to 3200 miles.

The returnable container system cost increased at a faster rate than the expendable container system cost. In other words, the transportation cost for the returnable container system increases faster than expendable with the increase in the delivery distance. According to the tapering principle, the graph should show the both container systems' cost increases at a decreasing rate. In this analysis, a fixed mileage rate (proportional rate) was used in the calculation, so the graph shows a linear relationship between the delivery distance and the container systems' cost. In any cases, the results agree to that the transportation cost for returnable container systems increases at a faster rate than for the expendable container systems. Therefore, the shorter the delivery distance, the greater is the chance for a returnable container system to be justified.

Figure 16 Impact of Delivery Distance for Low Cost Container Set

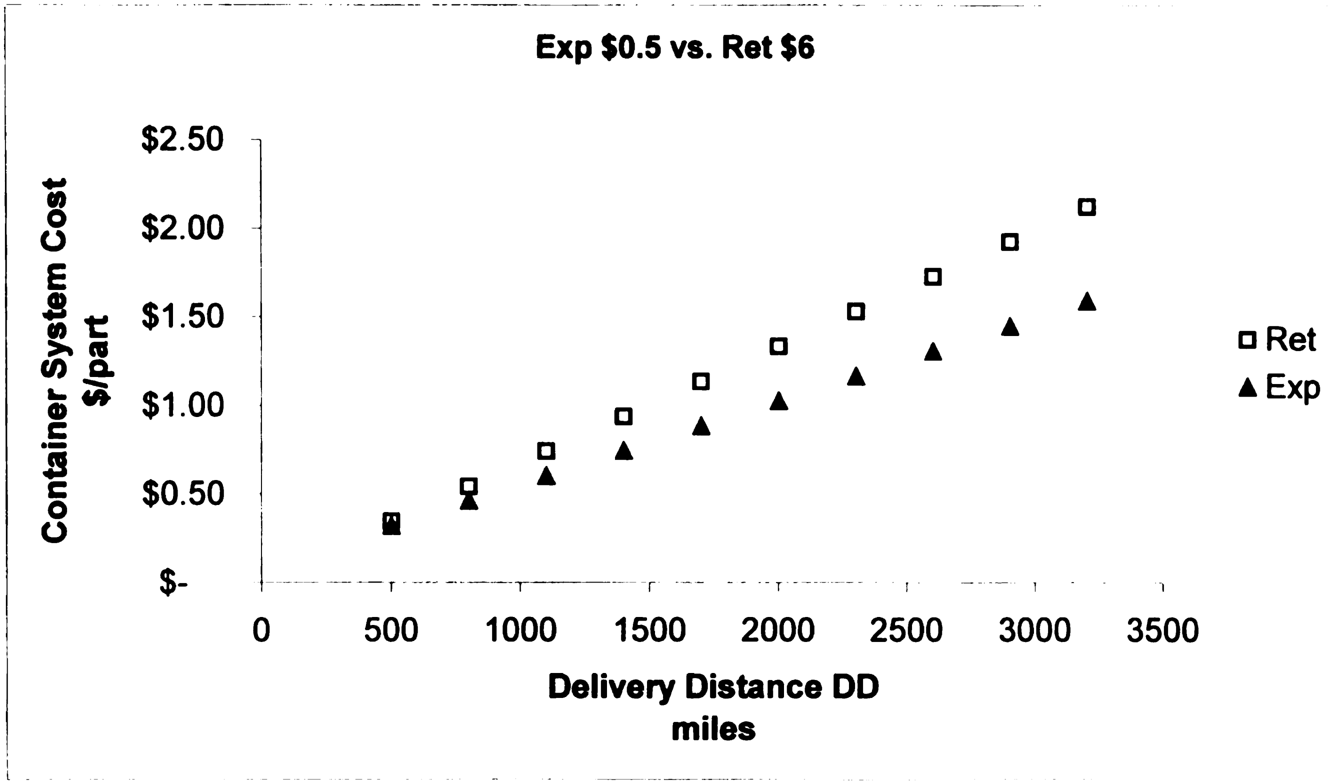

Table 21 Impact of Delivery Distance for Low Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	**DD**	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$6.00	3	1.3	10	1.1	2	3000	**500**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.3**	**$0.32**
$6.00	3	1.3	10	1.1	2	3000	**800**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.5**	**$0.46**
$6.00	3	1.3	10	1.1	2	3000	**1100**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.7**	**$0.60**
$6.00	3	1.3	10	1.1	2	3000	**1400**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$0.9**	**$0.74**
$6.00	3	1.3	10	1.1	2	3000	**1700**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.1**	**$0.88**
$6.00	3	1.3	10	1.1	2	3000	**2000**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.3**	**$1.02**
$6.00	3	1.3	10	1.1	2	3000	**2300**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.5**	**$1.16**
$6.00	3	1.3	10	1.1	2	3000	**2600**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.7**	**$1.31**
$6.00	3	1.3	10	1.1	2	3000	**2900**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$1.9**	**$1.45**
$6.00	3	1.3	10	1.1	2	3000	**3200**	1.41	1	0.38	18	**$0.50**	0.65	3	0.0475	**$2.1**	**$1.59**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 17 Impact of Delivery Distance for Mid Cost Container Set

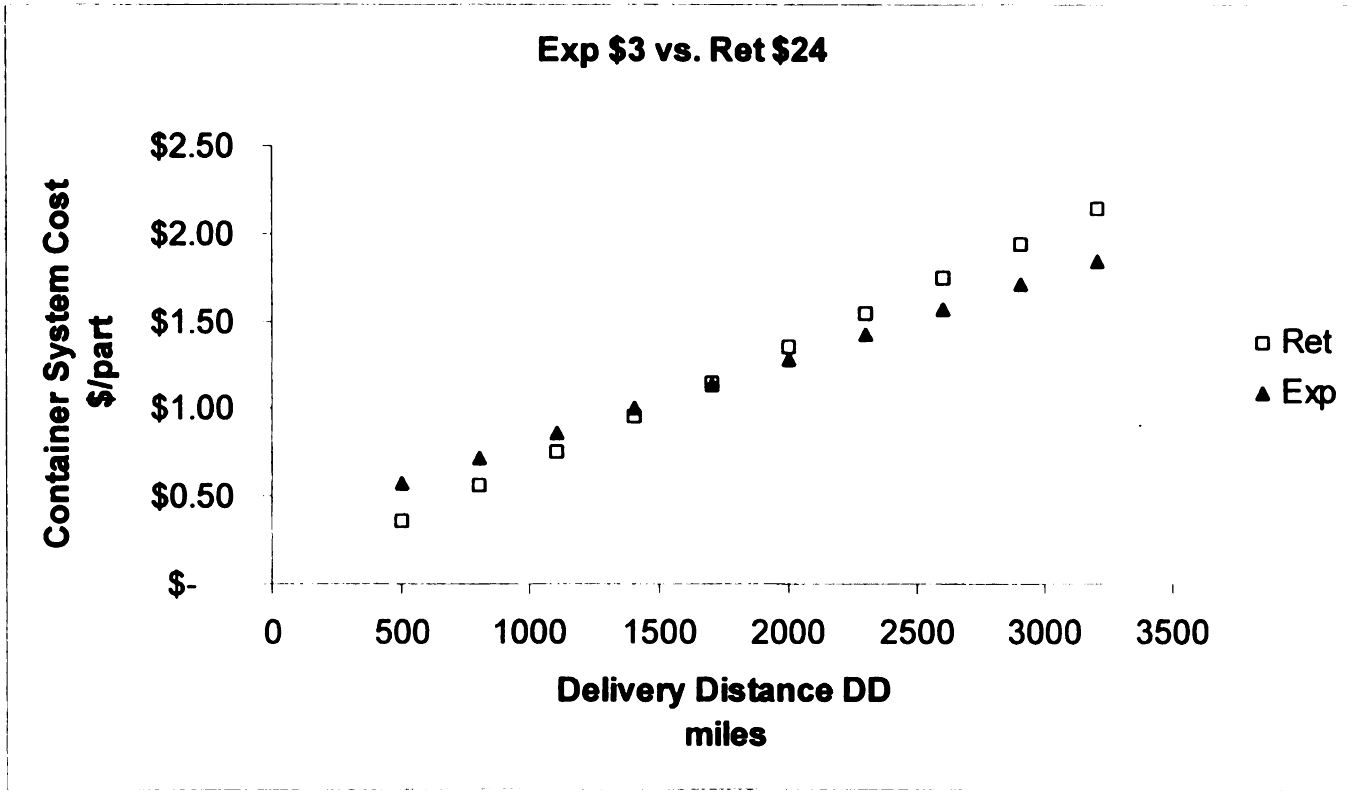

Table 22 Impact of Delivery Distance for Mid Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	**DD**	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$24.00	3	1.3	10	1.1	2	3000	**500**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.36**	**$0.58**
$24.00	3	1.3	10	1.1	2	3000	**800**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.56**	**$0.72**
$24.00	3	1.3	10	1.1	2	3000	**1100**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.76**	**$0.86**
$24.00	3	1.3	10	1.1	2	3000	**1400**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$0.95**	**$1.00**
$24.00	3	1.3	10	1.1	2	3000	**1700**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.15**	**$1.14**
$24.00	3	1.3	10	1.1	2	3000	**2000**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.35**	**$1.28**
$24.00	3	1.3	10	1.1	2	3000	**2300**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.55**	**$1.42**
$24.00	3	1.3	10	1.1	2	3000	**2600**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.74**	**$1.57**
$24.00	3	1.3	10	1.1	2	3000	**2900**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$1.94**	**$1.71**
$24.00	3	1.3	10	1.1	2	3000	**3200**	1.41	1	0.38	18	**$3.00**	0.65	5	0.0475	**$2.14**	**$1.85**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Figure 18 Impact of Delivery Distance for High Cost Container Set

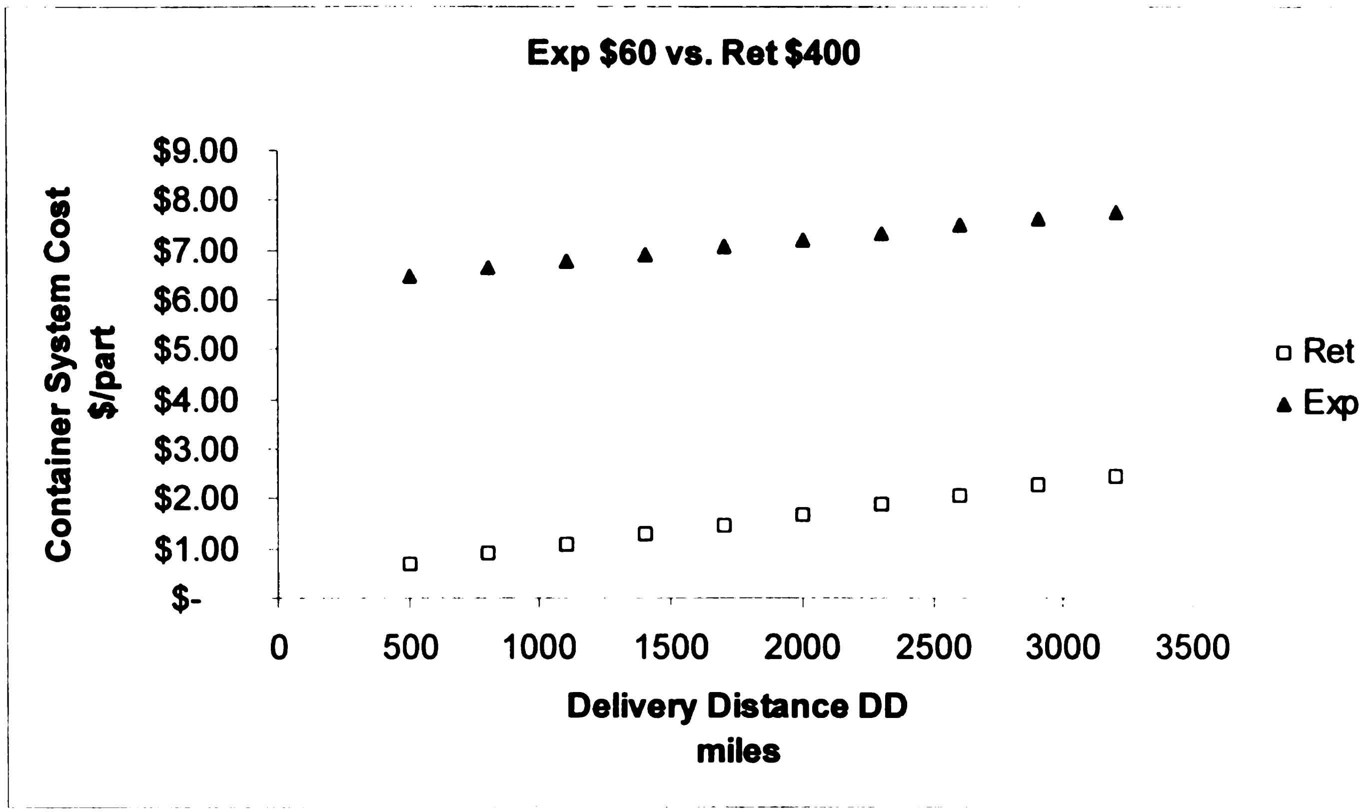

Table 23 Impact of Delivery Distance for High Cost Container Set

UCR	CT	PVF	PQ	CRR	CL	ADV	**DD**	MR	FOS	TR	LR	**UCE**	TE	CW	DR	**RCSC**	**ECSC**
$400.00	3	1.3	10	1.1	2	3000	**500**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.68**	**$6.49**
$400.00	3	1.3	10	1.1	2	3000	**800**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$0.88**	**$6.63**
$400.00	3	1.3	10	1.1	2	3000	**1100**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.08**	**$6.77**
$400.00	3	1.3	10	1.1	2	3000	**1400**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.28**	**$6.92**
$400.00	3	1.3	10	1.1	2	3000	**1700**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.47**	**$7.06**
$400.00	3	1.3	10	1.1	2	3000	**2000**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.67**	**$7.20**
$400.00	3	1.3	10	1.1	2	3000	**2300**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$1.87**	**$7.34**
$400.00	3	1.3	10	1.1	2	3000	**2600**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.07**	**$7.48**
$400.00	3	1.3	10	1.1	2	3000	**2900**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.26**	**$7.62**
$400.00	3	1.3	10	1.1	2	3000	**3200**	1.41	1	0.38	18	**$60.00**	0.65	50	0.0475	**$2.46**	**$7.76**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

Container Unit Cost (CUC)

The returnable container unit costs were increased from $6.25 to $62.50, and from $0.69 to $6.90 for the expendable containers. This increment is based on the assumption that the container cost increases at the one-to-nice ratio between the expendable and returnable containers cost. Although both the returnable and expendable container unit costs increase at the same rate, the impact of container unit cost on the expendable container system cost was much more dramatic than that on returnable container system cost. While the returnable container system cost varied from $0.42 to $0.53 per part, the expendable container system cost varied from $0.38 to $1.01. The results are presented in Figure 19 and Table 24.

The impact of the container unit cost over the container system cost was shown in the other variables. In general, the effect of container costs is a lot greater than the other variables, so the returnable container system can be more easily justified with the higher container cost.

The expendable container cost diminishes over the pack quantity only. On the other hand, the cost of returnable container diminishes over the pack quantity and number of usage over its lifetime, 500 trips for two years in this analysis.

When the expendable container cost is low, less than a dollar, the container cost can be absorbed by the pack quantity and result in lower system cost than returnable container system cost. However, the relatively expensive expendable container results in higher container system cost than the returnable container system cost considering return transportation cost.

Figure 19 Impact of Container Unit Cost

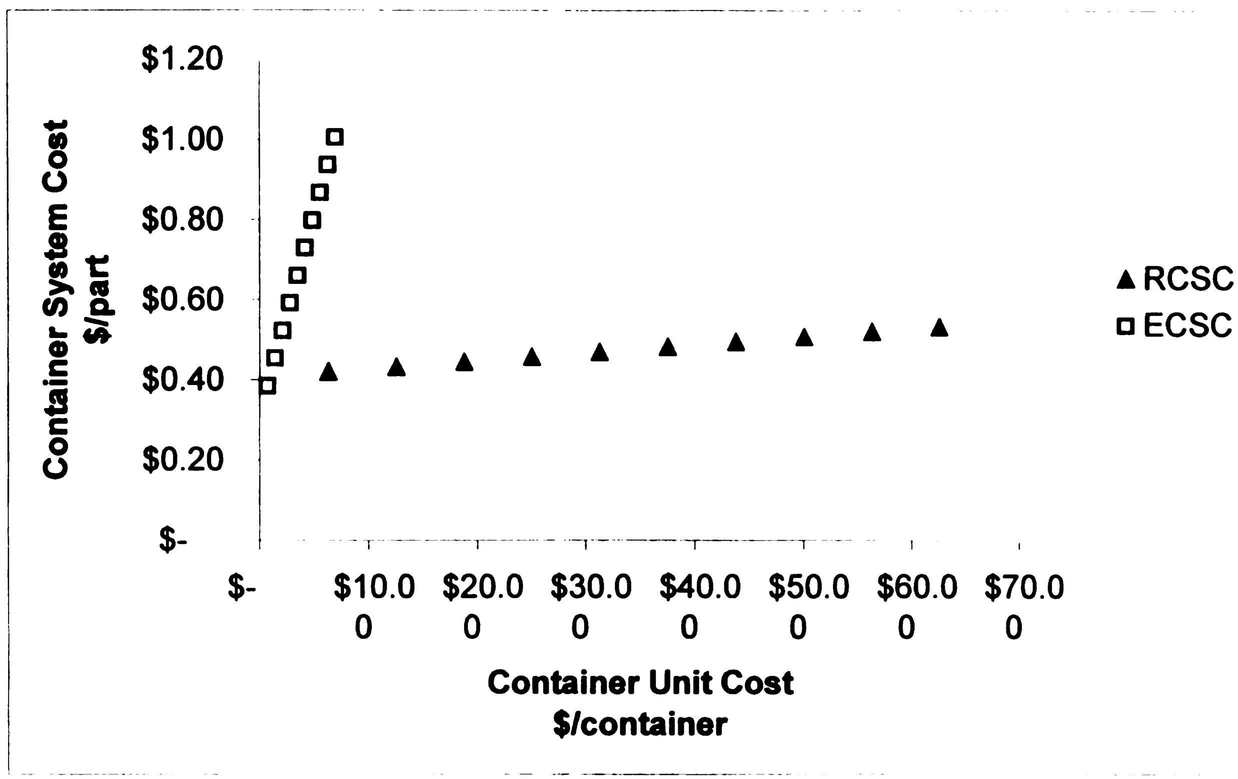

Table 24 Impact of Container Unit Cost

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC
$6.25	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$.69**	0.65	3	0.0475	**$0.4**	**$0.38**
$12.50	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$1.38**	0.65	3	0.0475	**$0.4**	**$0.45**
$18.75	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$2.07**	0.65	3	0.0475	**$0.4**	**$0.52**
$25.00	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$2.76**	0.65	3	0.0475	**$0.4**	**$0.59**
$31.25	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$3.45**	0.65	3	0.0475	**$0.4**	**$0.66**
$37.50	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$4.14**	0.65	3	0.0475	**$0.4**	**$0.73**
$43.75	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$4.83**	0.65	3	0.0475	**$0.4**	**$0.80**
$50.00	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$5.52**	0.65	3	0.0475	**$0.4**	**$0.87**
$56.25	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$6.21**	0.65	3	0.0475	**$0.4**	**$0.94**
$62.50	3	1.3	10	1.1	2	3000	60	1.41	1	0.38	18	**$6.90**	0.65	3	0.0475	**$0.4**	**$1.01**

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

RETURN RATIO (R_r)

Using collapsible/nestable returnable containers are often a trade-off between additional container costs vs. savings in transportation costs. Using collapsible/nestable returnable containers can reduce transportation cost. Since the collapsible/nestable returnable containers can be less volume when they are empty, the number of transports for the empties can be reduced by sending more empties per transport (increasing cubic efficiency for returning empties). For example, the returnable containers with a return ratio of one-to-three can reduce the return transportation cost by two third. On the other hand, the associated time spent accumulating collapsible/nestable returnable containers to their return ratio requires higher initial container quantities than when fully erected returnable containers are used.

Assuming the mileage rate is $1.41 and delivery distance is 1000 miles, the cost per one way trip *a* becomes $1,410/trip and the cost per two-way trip *b* becomes $1,974/trip. Let container unit cost *c* be $8.00 and container lifetime *l* be 2 years. The daily container consumptions are 300 containers and total of 500 trips takes place over 2 years period. According to the equation, the optimal return ratio is 0.065233. Table 25 shows the total cost (C_c + T_c) is minimized between 0.07 and 0.06, which is about 1 to 15 return ratio.

Table 25 Trade-offs between container cost vs. transportation cost

R_r	C_t	C_c	C_c+T_c
0.09	$730,380.00	$12,133.33	$742,513.33
0.08	$727,560.00	$13,800.00	$741,360.00
0.07	**$724,740.00**	**$15,942.86**	**$740,682.86**
0.06	**$721,920.00**	**$18,800.00**	**$740,720.00**
0.05	$719,100.00	$22,800.00	$741,900.00
0.04	$716,280.00	$28,800.00	$745,080.00
0.03	$713,460.00	$38,800.00	$752,260.00
0.02	$710,640.00	$58,800.00	$769,440.00
0.01	$707,820.00	$118,800.00	$826,620.00

In reality, however, the optimal return ratio of 0.065233 (about 1:15) is not available. The smallest return ratio available on the market today is container with one-to-ten return ratios, which is about 0.10. The reason for such huge gap is that the additional container cost is one-time cost that is amortized over container life. On the other hand, the transportation cost keeps occurring during the container lifetime.

Depends on the container unit cost, additional container quantities, and delivery distance, the optimal return ratio can be found. This optimal return ratio measures and balance the savings in transportation cost and additional container cost. In general, however, the transportation cost is a lot higher than the cost for additional containers. Unless there is a situation where container unit cost is high enough, and additional container quantity is high because the average volume is so big, and delivery distance is short that the investment on the additional containers can be bigger than the savings in the transportation cost, utilizing the nestable/collapsible containers decrease the total cost.

MULTI-VARIABLE ANALYSIS

Data Evaluation

The regressions run on the dependent variable, returnable container systems' cost minus expendable container systems' cost, contained the six independent variables. The results are reported in Tables 26-a, b, and c. These Tables report the t statistics and regression results, along with some additional diagnostic statistics. The various combinations of the six independent variables could account for 41 percent of the variation (see Table 26-a for R^2 value). Of the six independent variables, the container unit cost (CUC) was the most significant. The effects of the variables are in order of the most effect to the least effect:

1. Container Unit Cost (CUC): -8.3
2. Average Daily Volume (ADV): -0.41
3. Delivery Distance (DD): 0.31
4. Cycle Time (CT): 0.29
5. Pack Quantity (PQ): 0.22
6. Peak Volume Factor (PVF): 0.16

The estimated regression relationship for the savings is:

Savings (Ret - Exp) = 1.1796 + 0.279997 (cycle time) + 0.164684 (peak volume factor) + 0.222529 (pack quantity) - 0.409972 (average daily volume) + 0.30753 (delivery distance) - 8.316537 (container unit cost; expendable/returnable). Since the dependent variable is the returnable container system cost minus the expendable container system, the returnable container systems' cost is cheaper than the expendables' when the dependent variable is negative.

The interpretation of this equation is that the container unit cost and average daily volume has a negative effect upon savings (i.e. higher cost containers and higher average daily volume are negatively correlated with savings for expendables), while others have positive correlation with savings for expendable. The variables with a positive effect are cycle time (CT), peak volume factor (PVF), pack quantity (PQ), and delivery distance (DD). An increase in any of these variables is expected to decrease savings for returnable systems container. As mentioned in the methodology previously, the amount of increase expected wouldn't differ for each variable since the independent variables were deviated and standardized. The coefficients of the six variables then can be used to measure the impact.

The regression equation characteristics of savings indicate an R^2 of 0.41. This indicates that 41 percent of the variation in container systems' cost is explained by this equation. The order of the variables' entry into the regression equation is presented, as they are in Table 26-c. When the coefficient is used to indicate impact, the variable with the greatest effect is container unit cost (-8.316537), followed by average daily volume (-0.409972), delivery distance (0.30753), cycle time (0.279997), peak volume factor (0.164684), and pack quantity (0.222529). The results agree to the single variable analysis. The container unit cost has the most impact. The impact of the average daily volume and delivery distance has relatively higher impact than the cycle time, peak volume factor, and pack quantity. The peak volume factor has the least impact.

Table 26-a Regression Statistics

Regression Statistics	
Multiple R	0.641591
R Square	0.411639
Adjusted R Square	0.40675
Standard Error	0.690901
Observations	729

Table 26-b Analysis of Variance (ANOVA)

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	241.1248	40.18747	84.18971	7.79E-80
Residual	722	344.6425	0.477344		
Total	728	585.7674			

Table 26-c Regression Results with Additional Diagnostic Statistics

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.1796	0.114056	10.34226	1.8E-23	0.95567	1.403521
CT	0.279997	0.03134	8.934196	3.38E-18	0.21846	0.341525
PVF	0.164684	0.03134	5.254764	1.95E-07	0.10315	0.226212
PQ	0.222529	0.03134	7.100503	2.98E-12	0.16100	0.284057
ADV	-0.40997	0.03134	-13.0815	3.03E-35	-0.471	-0.34844
DD	0.30753	0.03134	9.812726	2.02E-21	0.24600	0.369058
CUC	-8.31654	0.930549	-8.93724	3.29E-18	-10.143	-6.48963

While the results presented thus far have focused on the level of savings variation explained by the regression equations, it is also helpful to indicate the amount of dependent variable variation not explained. In this study, the independent variables were not able to account for 59 percent of the variation. As noted previously, there are several other important cost drivers that were excluded. The author believes that some of the most important variables excluded in this analysis were the container return rate (*CRR*) and container lifetime (*CL*).

This analysis dealt only with the one to one relationship between a shipper and a consignee. There are many other reverse distribution system that may not agree to the results. For example, many companies utilizing milk run and cross dock facilities in order to reduce the transportation cost. Then, the savings with the milk run and cross-dock would be much greater for using returnable container system.

Another important limitation is that the use of linear regression equations suggests that the addition of one more unit of the independent variables will continue to produce a positive or a negative effect on a continual basis. Nonlinear specifications might provide useful insight on an optimal level of average daily volume, pack quantity, etc.

Manufacturing and Logistics System Profile

The results of the cost simulation are summarized in Table 27. Based on the individual variable analysis, the variables are placed in order that is in favor of expendable container system as the numbers move to the right. The actual simulation results are included in Appendix C, D, and E (C for low, D for mid, and E for high container cost). The categories of container represent three different level of container cost (low, mid, high). The actual costs used for each level are converted and shown as ratios. Within the colored areas, it is less expensive to use a returnable container system than an expendable container system. It does not mean that all the combinations within the shaded area are less expensive to use returnable containers. Each variable has 81 combinations, and the number of combinations that was savings for returnable container systems is converted to percentage and shown in the parenthesis underneath the variables. For example, if 2 out of 81 combinations were the savings for the returnable container systems, it would be shown as 2.5%. It should be noted that this profile is subject to change if the parameters change.

These results agree with the individual variable analyses. The individual analyses cannot be a direct comparison to the profile. However, the profile can be explained by the results from the individual variable. For the cycle time from 7 to 34 days, the returnable container system cost was always higher than the expendable container system cost when it was tested for the low cost container set (see Figure 4). The reason is that the system cost was calculated for the average daily volume of 3,000 (see Table 9). Recall that the returnable container system cost can be more easily justified with higher daily volume and higher cost containers. The profile shows that with the combination of the higher average daily volume, 10,000 parts per day, the savings for the returnable container system becomes possible.

Peak volume factor had relatively low impact on the overall container system cost, and the returnable container system was more expensive to use for the all peak volume factors tested (see Figure 10). However, the profile shows that the returnable container system can be less expensive to use for up to 50 percent daily fluctuations. As the peak volume factor was increased from 10 to 50 percent, the returnable container system cost increased from $0.4106 to $0.4121 per part (see Table 15). This increase is too low, even after the increase by cycle time is added, that the container system costs are driven by the average daily volume.

The pack quantity had a relatively low impact in as much as the less the pack quantity, the less expensive it can be to use the returnable container systems. However, the returnable container system cost was higher for the low cost container set (see Figure 13). The difference between the two container system costs was $0.0456 higher for the returnable container system when the pack quantity was 10 parts per container (see Table 18). This difference is still so small that the average daily volume can drive the savings for the returnable container system, but the savings is no longer available as the pack quantity becomes 50 parts per container.

The shorter the delivery distance, the greater is the chance for a returnable container system to be justified. The delivery distance of 500 miles is about the point where the returnable container system cost is about to be lower than the expendable container system cost (see Figure 16). Again, with the high average daily volume, the returnable container system can be justified in the profile, but the average daily volume is not big enough to justify the returnable container system when the delivery distance becomes 1,500 miles.

The impact of container unit cost was that the higher cost containers is greater than the other variables. The returnable container system can be more easily justified when the container cost is higher. In other word, the returnable container system cost is driven most by the container unit cost. The same observation can be made through the profile. When the container unit costs are low (first column), the economic justification of returnable container system is more constrained by the tight variables. As the container unit cost move onto mid and high cost container columns, the variable ranges become more open. The impact of unit cost is so great that the returnable container system still can be justified with the wide ranges of variables.

Table 27 Production and logistics profile for returnable container systems

Some important cost variables	**Container Category by unit cost**								
	Low Exp vs. Ret (1:12)			**Mid** Exp vs. Ret (1:8)			**High** Exp vs. Ret (1:6.7)		
Cycle time days	14 (2.5%)	28 (0.0%)	42 (0.0%)	14 (22.2%)	28 (8.6%)	42 (2.5%)	14 (86.4%)	28 (72.8%)	42 (39.5%)
Average daily volume parts	10,000 (2.5%)	5,000 (0.0%)	1,000 (0.0%)	10,000 (22.2%)	5,000 (11.1%)	1,000 (0.0%)	10,000 (84.0%)	5,000 (75.3%)	1,000 (39.5%)
Peak volume factor %	10 (1.2%)	50 (1.2%)	100 (0.0%)	10 (14.8%)	50 (11.1%)	100 (7.4%)	10 (82.7%)	50 (67.9%)	100 (48.1%)
Pack quantity parts	10 (2.5%)	50 (0.0%)	100 (0.0%)	10 (28.4%)	50 (4.9%)	100 (0.0%)	10 (85.2%)	50 (63.0%)	100 (50.6%)
Delivery Distance miles	500 (2.5%)	1,500 (0.0%)	3,000 (0.0%)	500 (19.8%)	1,500 (9.9%)	3,000 (3.7%)	500 (80.2%)	1,500 (64.2%)	3,000 (54.3%)

CHAPTER 5

DISCUSSION

This section discusses the results and gives recommendations for future research. Some of my internship experience at GM Powertrain during Fall 1999 was applied to this discussion.

SIGNIFICANT COST DRIVERS AND THEIR EFFECTS

The both of individual variable and multiple variable simulations agreed to that the cost of container was the most dominant cost driver among the six variables. The cost of the container is the most significant determinant if the returnable container system can be cost justified or not. If the container cost is low, it is less likely that the returnable container system can be cost justified and vice versa.

The expendable container unit cost is an expense that diminishes over the pack quantity while the returnable container investment is amortized over the number of parts held during the container lifetime. This explains why the automobile industry has been the leading manufacturers in using returnable container system. Automobile parts, such as engines and transmissions, require sturdy containers which are very expensive. For example, an engine racks costs six hundred dollars. The equivalent expendable container costs about two hundred dollars. In this case, the savings can be as much as seventeen dollars per engine.

The impact of average daily volume over the container system cost is relatively high. As the average daily volume increases, the returnable container system cost decreases at a faster rate than the expendable container system cost. Economies of scale can explain this. The high initial investment for the returnable container system decreases much faster as the average daily volume increases, and the decreasing rate decreases as the average daily volume becomes large because the investment diminishes over the large daily volume. Since this decreasing rate is faster for the returnable container system then expendable container, the returnable container system can be justified with the larger daily volume.

The delivery distance is also a cost driver. Distance has a great impact on the cost of a returnable container system. The transportation cost is always higher for the returnable than the expendable container systems due to return transportation cost, and this transportation cost gap becomes bigger with the increasing distance. With the shorter distance, the difference of transportation cost between the two container systems is smaller. Unless the savings from the container unit cost can surpass the additional transportation cost for back hauling, a returnable container system cannot be justified.

This research confirms that the pack quantity matters. In smaller sized packages with a lower pack quantity, returnable packages can be more cost effective than expendable, and it is true only when the both container unit cost are high enough to be sensitive to the changes in the pack quantities (see Figure 13, 14 and 15). As expressed in the equation for the Expendable Container Cost

(ECC) and the Returnable Container Cost (RCC), the pack quantity affects the unit cost of expendable container more directly than the unit cost of returnable container. The unit cost of an expendable container is amortized only by the pack quantity. But, since the unit cost of returnable container becomes low after the returnable container cost is amortized over its lifetime, the impact of pack quantity is not significant anymore. The continued popularity of just-in-time delivery strategies, under which items are delivered to the production line in small lot-size quantities, is one factor that has helped to stimulate a growing interest in returnable containers.

The cycle time and peak volume factor does impact the overall container system cost, but the impact is relatively low. The cycle time and peak volume factor measure the additional containers that need to be purchased for the increased cycle time and demand fluctuations. This additional container investment is not significant after the cost is amortized over the container life.

OPTIMAL RETURN RATIO

Many companies are trying to utilize the benefits of collapsible/nestable returnable containers to decrease storage space and return transportation cost. On the other hand, the additional containers have to be purchased for a longer container cycle time due to the longer waiting to accumulate a cubic volume, such as a truckload of empties, which minimizes return transport cost. The optimal return ratio that balances the trade-off between the decrease in transportation cost and the increase in initial investment was found. The optimal return ratio found in this study was about one-to-fifteen (1:15), which is smaller than what is available on the market (1:10). The reason is that the transportation cost is a lot higher than the investment for the additional containers. The collapsible/nestable returnable containers with the lower return ratio can give more savings than using fully erected containers. Using the fully erected containers minimizes the initial investments in the container fleet, but the savings in return transport cost by using collapsible/nestable containers can be a lot greater unless the container cost is so high that purchasing additional container can be more expensive than the savings in the return transport cost.

However, the management of a returnable container system is already complex. Using collapsible/nestable returnable containers increases the complexity of management. For example, if filled containers with a one-to-three return ratio come into a facility palletized three high, the emptied containers can be palletized nine high for return. This means that two returnable pallets are left without any containers, which have a high possibility of being misplaced or not being returned to suppliers with the corresponding containers that came in with.

PRODUCTION AND LOGISTICS STRUCTURE

The manufacturing and logistics profile (Table 27) shows the appropriate production and logistics structure in which the returnable container system can be cost justified. With the given sets of parameters, it was found that the ranges turned out to be relatively narrow for the low cost containers. As the container cost increased, the range becomes wider.

When comparing the expendable container at $0.5 to the returnable container at $6 (low cost containers at ratio of 1:12), the appropriate production and logistics structures are when the cycle time is 14 days or less, the average daily volume is 10,000 parts or more, the peak volume factor is 50 percent or less, the pack quantity is 10 parts or less, and the delivery distance is 500 miles or less. These combinations represent only 2 out of 243 (0.82%) combinations. Recall the amortized returnable container cost becomes lower than the expendables (see Table 1). However, the unit cost of containers is so low that the savings on the packaging material cost from using the returnable containers cannot justify the return transportation cost for empties. It is difficult to justify the returnable container system for low cost containers.

When comparing the expendable container at $3 to the returnable container at $24 (mid cost containers at ratio of 1:8), more combinations are cost justified for returnable container systems. 27 out of 243 combinations (11.1%) turned out to be cost justified for returnable container systems. The appropriate production and logistics systems is when the cycle time is less than 28 days, the average daily volume is more than 5,000 parts, the peak volume factor is less than 100 percent, the pack quantity is 50 parts, and the delivery distance is less than 3,000 miles. With the increased container cost, the savings on the packaging material cost becomes big enough to pay off the return transportation cost, and allow longer delivery distance, more pack quantities, higher fluctuations in daily demand, smaller average daily volume and longer container cycle times than it was for low cost containers. Although the mid cost container can be more easily cost justified, the savings on the packaging material cost by using returnable containers is not still big enough to be cost justified for the all the combinations.

This impact becomes bigger when comparing higher cost containers, a $60 expendable container to a $400 returnable container. In this case, 161 out of 243 combinations (66.3%) were favor to the returnable container systems. As the unit cost of container become higher, the savings on packaging material become bigger. The bigger savings can pay off the cost associated with the longer cycle time, longer delivery distance, higher demand fluctuations, and less daily volume, and more pack quantities.

The profile visualizes the manufacturing and logistics system, so that a company can improve the system setting under which the returnable container system can be justified. For most logistics structures with low container costs, it is shown that the returnable container systems cannot easily be cost justified. This explains why the automobile industry is still utilizing expendable containers for small parts, such as fasteners. Usually, a 9 x 9 x 5 container can hold between 1000 and 8000 fasteners depending on the size of fasteners. The cost of this expendable container is low, and when the low container cost diminishes over the high pack quantity that the amortized, savings from returnable container is not significant to cover the return transport cost.

In order to improve this situation, Automobile Industry Action Group (AIAG) has been working on using a standardized returnable container for the fasteners between Ford, GM, and Daimler Chrysler. The expected benefits and savings from the project can be shown in the results of this research. Although

Ford, GM, and Daimler Chrysler are separate automobile manufacturers, if they share a standardized container they can be considered as one huge company. In other words, the daily volume subject to the container would be a lot higher than when they utilized three different kinds. From the analysis, it is known that as the daily volume increases, there is better chance for the returnable container system cost to be justified. At the same time, container unit cost will decrease due to the high container volume to be purchased (quantity break). Service charge from suppliers should also decrease since they do not have to sort three different containers.

MANAGEMENT IMPLICATIONS

The results of this study have provided insight into some prediction factors that have an important impact in explaining the variation in savings for returnable container systems. The findings from this study should assist in developing a set of activities in manufacturing and logistics systems that can potentially help their savings in distribution system. What is most significant in this regard is that those factors found to drive the savings in using returnable container systems were container unit cost, average daily volume, and delivery distance.

The characteristic of average daily volume is that the larger the average daily volume, the bigger the savings can be. It is not possible to increase the daily volume over night to justify the container system. However, there are many ways that can improve the situations. The consolidation and standardization of containers increases the average daily volume subject to that container without increasing the actual volume. The delivery distance can be tweaked by utilizing the milk run and cross-dock. The milk run and cross-dock reduces the transportation cost without decreasing the physical distance.

Cycle time, peak volume factor, and pack quantity didn't affect the savings of returnable container system as much as the other three. However, the degree of effects increased with the higher container cost. Developing a set of strategies support the short cycle time, low in daily volume fluctuation, and small lot pack quantity can maximize the savings in use of returnable container system. These characteristics of returnable container system overlap just-in-time and postponement manufacturing environment. These applications have been driven more by marketing strategies that the packaging system is not incorporated. Implementation of returnable container system can increase the benefits of those applications and overall material flow system.

This study also quantified the importance of other cost involved in the returnable container systems besides the packaging material cost. Two main cost involved in the returnable container system are packaging material cost and transportation cost. If the savings in the packaging material is larger than the additional transportation cost for back hauling empties, the returnable container system is more likely cost justified as long as the packaging material cost is based on the descent values of cycle time, average daily volume, peak volume factor, and pack quantity.

Same variables were tested for three different cost container sets. For the low cost containers, the findings suggest that the implementing the returnable container system is hardly cost justified. Even if the returnable container system can be cost justified, the savings wouldn't be big enough to sacrifice the complexity involved in the two-way flow systems. The returnable container systems are more recommended for the mid and high cost containers.

The results suggest that the production and logistics systems have to be planned accordingly in order to justify economics of returnable container system. Recall Table 1 (Lifetime Cost Comparison of One-Way and Reusable 2-cubic Foot Shipping Containers, by Material) shows the reason how returnable container pays itself as the cost of returnable container amortized over its life. Using the numbers in the table, it was \$11.03 returnable container vs. \$0.53 expendables. Simply thinking, if the returnable container can be used 21 times $\left(\frac{\text{Initial cost of returnable}}{\text{Initial cost of returnable}} = \frac{\$11.05}{\$0.53} \approx 20\right)$, the investment evens out and savings starts. However, the accuracy of this estimation is not good because of the factors discussed previously. Even if the returnable container can be used infinite times, the maximum savings can be expected is about \$0.53. This is the maximum savings can be achieved without consider the other variables that make up the actual returnable packaging material cost. After considering the other variables, the saving must be decreased. Assume that the saving become \$0.25 after considering every other variable. Then, there is return transportation cost that has to be paid off before the savings can start.

FUTURE RESEARCH RECOMMENDATIONS

This report provides an understating of some important cost variables and the manufacturing and logistics system profile for returnable container systems.

It can be useful to decision-makers who are considering a returnable packaging system.

But through my internship experience at GM and the literature, I have found that there are still plenty of cost and operational concerns after a returnable system is adopted. An important area of potential research is in the area of strategies for returnable packaging logistics management. I found the information system must to be established along with the returnable container implementation. The loss and misplacement of empties represent a significant amount of money. The container shortage due to the lost has to be replaced. The misplaced empties have to be expedited to the right place with premium transportation cost. In worst case, the production line has to be shut down or the product is not available for sale because the containers were not available. It is crucial to acknowledge the importance of container flow management. It is important to develop a system that better integrates the container systems.

The complexity of a multi-location returnable container system is much greater than the way it has been represented in this model. There are so many activities incorporated in returnable container systems that a container can cause a company to lose a lot more money than savings from the returnable container itself. It may be easy to show that the implementation of returnable container systems could save millions of dollars in the cost analysis. Without the adequate management, the use of returnable container systems is nothing more than headache.

The economic benefits of returnable container system are not something that can just happen. It has to be earned. Many practitioner articles state that using the returnable container system can save a lot of money, but they do not emphasize enough how hard it is to implement and manage the returnable container system. It is true that using returnable container system can save money. However, savings are not what is shown in the predictive calculation; they are in the execution.

APPENDICES

APPENDIX A

A GUIDE TO RETURNABLE CONTAINERS AND RACKS (PASHALL 1986)

Type	Load capacities (dynamic)	Dimensions	Collapsed container return ratio	Application notes
Modular container system	Pallet-4,000 lb, containers-300 to 1,200 lb	45- x 48-in. or 32- x 30-in. pallet; 2, 4, 6, 8, or 9 containers per pallet.	3:1	Good for small, standard-parts handling. Tote boxes in a variety of sizes fit onto a special pallet. Containers nest and stack.
Collapsible polyethylene bin	1,200 to 4,000 lb	32 x 30 x 34 in. high to 53 x 43 x 35 in. high	3:1	Lightweight container for large parts. Some models feature tops and gates for access when stacked. Can be stacked 6 high at rated capacity.
Collapsible steel-mesh bin and corrugated steel bin	Up to 4,000 lb	20 x 32 x 16 in. high to 48 x 48 x 30 in. high	5:1 and 4:1	In general, heavier load capacities than plastic bins. Extremely durable and damage resistant.
Copolymer-foam tray system	Varies	Varies according to application	3:1	Foam trays interlock and fit between plastic lids secured by strapping. Provides good shock and abrasion protection.
Corrugated cardboard bulk container system	Up to 3,500 lb	32 x 44 x 36 in. high to 44 x 58.5 x 36 in. high	10:1	Corrugated sleeve fits between plastic lids. Inexpensive and lightweight bulk container. Can be stacked 4 high at rated capacity.
Collapsible, adjustable polyethylene	Up to 2,000 lb	Width from 48 to 67 in.; Height from 50 to 54 in.; Length 96 in.	3:1	Less than half the weight of a conventional, heavy-duty steel rack. Height and width adjust in 1-in. increments.

rack				
Collapsible steel rack	Up to 3,000 lb	Width from 51 to 71 in.; Height 51 in.; Length 96 in.	4:1	About 20% lighter than a conventional steel rack. Useful for shipping bulky loads.

APPENDIX B

COMPARING CONTAINER PERFORMANCE AND COST (TRUCK 1993)

	One-Way Corrugated Paper	Returnable Corrugated Paper	Vacuum Form	Structural Foam	Injection Molded	Compression Molded Fiberglass
Finish Wt. (lbs)	1.0	1.5	6.1	9.0	4.9	9.3
Mominal Load (lbs)	40	40	70	100	70	500
Stack Strength (lbs)	nil	20	1,000	1,500	1,000	3,500
Unit Cost ($)	.50	.80	10.00	11.50	5.00	12.50
Expected Trip Cycles	1	5	200	250	250	1,000+
Cost per Trip ($)	.50	.16	.05	.05	.02	.01
Lead Time for Mfg. (wks)	1	1	8	24	30	30

This chart compares data on various kinds of corrugated and plastic containers used in a returnable container shipping system. all the containers were the same size at 1.6 cu ft. Finish weight is the are weight of an empty container. Nominal load is the average load each container holds. Stack strength is the most weight the container on the bottom of a stack can support. Unit cost and manufacturing lead time for the container s are merely for comparison.

APPENDIX C

MULTIPLE VARIABLE SIMULATION DATA FOR LOW COST CONTAINER

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC	RCSC-ECSC
6	14	1.1	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1304	0.1448	-0.0143
6	14	1.5	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1378	0.1448	-0.0069
6	14	2	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1471	0.1448	0.0023
6	28	1.1	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1508	0.1448	0.0060
6	14	1.1	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2291	0.2153	0.0139
6	14	1.1	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1050	0.0854	0.0197
6	28	1.5	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1655	0.1448	0.0208
6	14	1.5	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1065	0.0854	0.0212
6	14	1.5	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2365	0.2153	0.0213
6	14	2	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1084	0.0854	0.0230
6	28	1.1	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1091	0.0854	0.0238
6	14	1.1	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1019	0.0779	0.0239
6	14	1.5	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1026	0.0779	0.0247
6	14	2	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1035	0.0779	0.0256
6	28	1.1	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1039	0.0779	0.0260
6	42	1.1	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1711	0.1448	0.0263
6	28	1.5	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1121	0.0854	0.0267
6	28	1.5	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1054	0.0779	0.0275
6	42	1.1	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1132	0.0854	0.0278
6	42	1.1	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1059	0.0779	0.0280
6	28	2	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1072	0.0779	0.0293
6	42	1.5	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1082	0.0779	0.0302

6	28	2	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1158	0.0854	0.0304
6	14	2	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2458	0.2153	0.0305
6	42	1.5	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1176	0.0854	0.0323
6	42	2	100	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1109	0.0779	0.0330
6	28	1.1	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2495	0.2153	0.0342
6	42	2	50	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1232	0.0854	0.0378
6	28	2	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1840	0.1448	0.0393
6	14	1.1	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3278	0.2858	0.0421
6	14	1.1	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2037	0.1559	0.0479
6	42	1.5	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.1933	0.1448	0.0485
6	28	1.5	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2642	0.2153	0.0490
6	14	1.5	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2052	0.1559	0.0494
6	14	1.5	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3352	0.2858	0.0495
6	14	2	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2071	0.1559	0.0512
6	28	1.1	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2078	0.1559	0.0520
6	14	1.1	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2006	0.1484	0.0521
6	14	1.5	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2013	0.1484	0.0529
6	14	2	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2022	0.1484	0.0538
6	28	1.1	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2026	0.1484	0.0542
6	42	1.1	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2698	0.2153	0.0545
6	28	1.5	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2108	0.1559	0.0549
6	28	1.5	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2041	0.1484	0.0557
6	42	1.1	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2119	0.1559	0.0560
6	42	1.1	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2046	0.1484	0.0562
6	28	2	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2059	0.1484	0.0575
6	42	1.5	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2069	0.1484	0.0584
6	28	2	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2145	0.1559	0.0586
6	14	2	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3445	0.2858	0.0587
6	42	1.5	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2163	0.1559	0.0605
6	42	2	100	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2096	0.1484	0.0612

6	28	1.1	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3482	0.2858	0.0624
6	42	2	50	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2219	0.1559	0.0660
6	28	2	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2827	0.2153	0.0675
6	14	1.1	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3024	0.2264	0.0761
6	42	2	10	1.1	2	10000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2210	0.1448	0.0762
6	42	1.5	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2920	0.2153	0.0767
6	28	1.5	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3629	0.2858	0.0772
6	14	1.5	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3039	0.2264	0.0776
6	14	2	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3058	0.2264	0.0794
6	28	1.1	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3065	0.2264	0.0802
6	14	1.1	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.2993	0.2189	0.0803
6	14	1.5	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3000	0.2189	0.0811
6	14	2	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3009	0.2189	0.0820
6	28	1.1	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3013	0.2189	0.0824
6	42	1.1	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3685	0.2858	0.0827
6	28	1.5	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3095	0.2264	0.0831
6	28	1.5	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3028	0.2189	0.0839
6	42	1.1	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3106	0.2264	0.0842
6	42	1.1	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3033	0.2189	0.0844
6	28	2	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3046	0.2189	0.0857
6	42	1.5	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3056	0.2189	0.0866
6	28	2	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3132	0.2264	0.0868
6	42	1.5	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3150	0.2264	0.0887
6	42	2	100	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3083	0.2189	0.0894
6	42	2	50	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3206	0.2264	0.0942
6	28	2	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3814	0.2858	0.0957
6	42	2	10	1.1	2	5000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3197	0.2153	0.1044
6	42	1.5	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.3907	0.2858	0.1049
6	14	1.1	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6239	0.4973	0.1267
6	14	1.1	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6239	0.4973	0.1267

6	42	2	10	1.1	2	10000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.4184	0.2858	0.1326
6	14	1.5	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6313	0.4973	0.1341
6	14	1.5	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6313	0.4973	0.1341
6	14	2	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6406	0.4973	0.1433
6	14	2	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6406	0.4973	0.1433
6	28	1.1	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6443	0.4973	0.1470
6	28	1.1	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6443	0.4973	0.1470
6	14	1.1	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5985	0.4379	0.1607
6	14	1.1	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5985	0.4379	0.1607
6	28	1.5	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6590	0.4973	0.1618
6	28	1.5	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6590	0.4973	0.1618
6	14	1.5	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6000	0.4379	0.1622
6	14	1.5	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6000	0.4379	0.1622
6	14	2	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6019	0.4379	0.1640
6	14	2	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6019	0.4379	0.1640
6	28	1.1	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6026	0.4379	0.1648
6	28	1.1	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6026	0.4379	0.1648
6	14	1.1	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5954	0.4304	0.1649
6	14	1.1	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5954	0.4304	0.1649
6	14	1.5	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5961	0.4304	0.1657
6	14	1.5	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5961	0.4304	0.1657
6	14	2	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5970	0.4304	0.1666
6	14	2	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5970	0.4304	0.1666
6	28	1.1	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5974	0.4304	0.1670
6	28	1.1	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5974	0.4304	0.1670
6	42	1.1	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6646	0.4973	0.1673
6	42	1.1	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6646	0.4973	0.1673
6	28	1.5	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6056	0.4379	0.1677
6	28	1.5	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6056	0.4379	0.1677
6	28	1.5	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5989	0.4304	0.1685

6	28	1.5	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5989	0.4304	0.1685
6	42	1.1	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6067	0.4379	0.1688
6	42	1.1	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6067	0.4379	0.1688
6	42	1.1	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5994	0.4304	0.1690
6	42	1.1	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.5994	0.4304	0.1690
6	28	2	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6007	0.4304	0.1703
6	28	2	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6007	0.4304	0.1703
6	42	1.5	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6017	0.4304	0.1712
6	42	1.5	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6017	0.4304	0.1712
6	28	2	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6093	0.4379	0.1714
6	28	2	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6093	0.4379	0.1714
6	42	1.5	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6111	0.4379	0.1733
6	42	1.5	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6111	0.4379	0.1733
6	42	2	100	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6044	0.4304	0.1740
6	42	2	100	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6044	0.4304	0.1740
6	42	2	50	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6167	0.4379	0.1788
6	42	2	50	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6167	0.4379	0.1788
6	28	2	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6775	0.4973	0.1803
6	28	2	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6775	0.4973	0.1803
6	42	1.5	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6868	0.4973	0.1895
6	42	1.5	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.6868	0.4973	0.1895
6	42	2	10	1.1	2	5000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.7145	0.4973	0.2172
6	42	2	10	1.1	2	10000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.7145	0.4973	0.2172
6	14	1.1	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0187	0.7793	0.2395
6	14	1.5	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0261	0.7793	0.2469
6	14	2	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0354	0.7793	0.2561
6	28	1.1	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0391	0.7793	0.2598
6	14	1.1	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9933	0.7199	0.2735
6	28	1.5	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0538	0.7793	0.2746
6	14	1.5	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9948	0.7199	0.2750

6	14	2	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9967	0.7199	0.2768
6	28	1.1	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9974	0.7199	0.2776
6	14	1.1	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9902	0.7124	0.2777
6	14	1.5	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9909	0.7124	0.2785
6	14	2	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9918	0.7124	0.2794
6	28	1.1	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9922	0.7124	0.2798
6	42	1.1	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0594	0.7793	0.2801
6	28	1.5	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0004	0.7199	0.2805
6	28	1.5	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9937	0.7124	0.2813
6	42	1.1	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0015	0.7199	0.2816
6	42	1.1	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9942	0.7124	0.2818
6	28	2	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9955	0.7124	0.2831
6	42	1.5	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9965	0.7124	0.2840
6	28	2	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0041	0.7199	0.2842
6	42	1.5	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0059	0.7199	0.2861
6	42	2	100	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	0.9992	0.7124	0.2868
6	42	2	50	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0115	0.7199	0.2916
6	28	2	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0723	0.7793	0.2931
6	14	1.1	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2161	0.9203	0.2959
6	42	1.5	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.0816	0.7793	0.3023
6	14	1.5	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2235	0.9203	0.3033
6	14	2	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2328	0.9203	0.3125
6	28	1.1	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2365	0.9203	0.3162
6	14	1.1	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1907	0.8609	0.3299
6	42	2	10	1.1	2	1000	500	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1093	0.7793	0.3300
6	28	1.5	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2512	0.9203	0.3310
6	14	1.5	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1922	0.8609	0.3314
6	14	2	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1941	0.8609	0.3332
6	28	1.1	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1948	0.8609	0.3340
6	14	1.1	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1876	0.8534	0.3341

6	14	1.5	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1883	0.8534	0.3349
6	14	2	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1892	0.8534	0.3358
6	28	1.1	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1896	0.8534	0.3362
6	42	1.1	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2568	0.9203	0.3365
6	28	1.5	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1978	0.8609	0.3369
6	28	1.5	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1911	0.8534	0.3377
6	42	1.1	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1989	0.8609	0.3380
6	42	1.1	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1916	0.8534	0.3382
6	28	2	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1929	0.8534	0.3395
6	42	1.5	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1939	0.8534	0.3404
6	28	2	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2015	0.8609	0.3406
6	42	1.5	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2033	0.8609	0.3425
6	42	2	100	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.1966	0.8534	0.3432
6	42	2	50	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2089	0.8609	0.3480
6	28	2	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2697	0.9203	0.3495
6	42	1.5	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.2790	0.9203	0.3587
6	42	2	10	1.1	2	5000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	1.3067	0.9203	0.3864
6	14	1.1	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9927	2.1893	0.8035
6	14	1.5	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0001	2.1893	0.8109
6	14	2	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0094	2.1893	0.8201
6	28	1.1	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0131	2.1893	0.8238
6	14	1.1	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9673	2.1299	0.8375
6	28	1.5	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0278	2.1893	0.8386
6	14	1.5	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9688	2.1299	0.8390
6	14	2	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9707	2.1299	0.8408
6	28	1.1	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9714	2.1299	0.8416
6	14	1.1	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9642	2.1224	0.8417
6	14	1.5	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9649	2.1224	0.8425
6	14	2	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9658	2.1224	0.8434
6	28	1.1	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9662	2.1224	0.8438

6	42	1.1	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0334	2.1893	0.8441
6	28	1.5	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9744	2.1299	0.8445
6	28	1.5	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9677	2.1224	0.8453
6	42	1.1	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9755	2.1299	0.8456
6	42	1.1	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9682	2.1224	0.8458
6	28	2	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9695	2.1224	0.8471
6	42	1.5	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9705	2.1224	0.8480
6	28	2	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9781	2.1299	0.8482
6	42	1.5	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9799	2.1299	0.8501
6	42	2	100	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9732	2.1224	0.8508
6	42	2	50	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	2.9855	2.1299	0.8556
6	28	2	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0463	2.1893	0.8571
6	42	1.5	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0556	2.1893	0.8663
6	42	2	10	1.1	2	1000	1500	1.41	1	0.38	1	0.5	0.65	1	0.0475	3.0833	2.1893	0.8940
6	14	1.1	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9537	4.3043	1.6495
6	14	1.5	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9611	4.3043	1.6569
6	14	2	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9704	4.3043	1.6661
6	28	1.1	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9741	4.3043	1.6698
6	14	1.1	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9283	4.2449	1.6835
6	28	1.5	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9888	4.3043	1.6846
6	14	1.5	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9298	4.2449	1.6850
6	14	2	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9317	4.2449	1.6868
6	28	1.1	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9324	4.2449	1.6876
6	14	1.1	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9252	4.2374	1.6877
6	14	1.5	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9259	4.2374	1.6885
6	14	2	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9268	4.2374	1.6894
6	28	1.1	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9272	4.2374	1.6898
6	42	1.1	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9944	4.3043	1.6901
6	28	1.5	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9354	4.2449	1.6905
6	28	1.5	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9287	4.2374	1.6913

6	42	1.1	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9365	4.2449	1.6916
6	42	1.1	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9292	4.2374	1.6918
6	28	2	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9305	4.2374	1.6931
6	42	1.5	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9315	4.2374	1.6940
6	28	2	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9391	4.2449	1.6942
6	42	1.5	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9409	4.2449	1.6961
6	42	2	100	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9342	4.2374	1.6968
6	42	2	50	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	5.9465	4.2449	1.7016
6	28	2	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	6.0073	4.3043	1.7031
6	42	1.5	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	6.0166	4.3043	1.7123
6	42	2	10	1.1	2	1000	3000	1.41	1	0.38	1	0.5	0.65	1	0.0475	6.0443	4.3043	1.7400

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

APPENDIX D

MULTIPLE VARIABLE SIMULATION DATA FOR MID COST CONTAINER

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC	RCSC-ECSC
24	14	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1914	0.4043	-0.2128
24	14	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2901	0.4748	-0.1846
24	14	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2210	0.4043	-0.1833
24	14	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3888	0.5453	-0.1564
24	14	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3197	0.4748	-0.1551
24	14	2	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2579	0.4043	-0.1463
24	28	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2727	0.4043	-0.1315
24	14	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4184	0.5453	-0.1269
24	14	2	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3566	0.4748	-0.1181
24	28	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3714	0.4748	-0.1033
24	14	2	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4553	0.5453	-0.0899
24	28	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4701	0.5453	-0.0751
24	28	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3319	0.4043	-0.0724
24	14	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6849	0.7568	-0.0718
24	14	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6849	0.7568	-0.0718
24	42	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3540	0.4043	-0.0502
24	28	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4306	0.4748	-0.0442
24	14	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.7145	0.7568	-0.0423
24	14	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.7145	0.7568	-0.0423
24	42	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4527	0.4748	-0.0220
24	14	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1172	0.1373	-0.0200
24	28	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.5293	0.5453	-0.0160

24	14	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1232	0.1373	-0.0141
24	14	2	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1305	0.1373	-0.0067
24	14	2	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.7514	0.7568	-0.0053
24	14	2	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.7514	0.7568	-0.0053
24	28	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1335	0.1373	-0.0037
24	28	2	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4058	0.4043	0.0015
24	14	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1080	0.1039	0.0041
24	42	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.5514	0.5453	0.0062
24	14	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1109	0.1039	0.0071
24	28	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1453	0.1373	0.0081
24	14	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2159	0.2078	0.0082
24	28	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.7662	0.7568	0.0095
24	28	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.7662	0.7568	0.0095
24	14	2	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1146	0.1039	0.0107
24	28	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1161	0.1039	0.0122
24	42	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1498	0.1373	0.0125
24	14	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2219	0.2078	0.0141
24	28	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1220	0.1039	0.0181
24	42	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1242	0.1039	0.0204
24	14	2	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2292	0.2078	0.0215
24	28	2	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1601	0.1373	0.0229
24	28	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2322	0.2078	0.0245
24	28	2	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1294	0.1039	0.0255
24	42	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1331	0.1039	0.0292
24	28	2	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.5045	0.4748	0.0297
24	42	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1675	0.1373	0.0303
24	14	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2067	0.1744	0.0323
24	14	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2096	0.1744	0.0353
24	28	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2440	0.2078	0.0363
24	14	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3146	0.2783	0.0364

24	42	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.4427	0.4043	0.0385
24	14	2	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2133	0.1744	0.0389
24	42	2	100	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1442	0.1039	0.0403
24	28	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2148	0.1744	0.0404
24	42	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2485	0.2078	0.0407
24	14	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0797	1.0388	0.0410
24	14	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3206	0.2783	0.0423
24	28	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2207	0.1744	0.0463
24	42	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2229	0.1744	0.0486
24	14	2	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3279	0.2783	0.0497
24	28	2	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2588	0.2078	0.0511
24	42	2	50	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.1897	0.1373	0.0524
24	28	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3309	0.2783	0.0527
24	28	2	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2281	0.1744	0.0537
24	42	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2318	0.1744	0.0574
24	28	2	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6032	0.5453	0.0579
24	42	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2662	0.2078	0.0585
24	14	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3054	0.2449	0.0605
24	14	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3083	0.2449	0.0635
24	28	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3427	0.2783	0.0645
24	42	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.5414	0.4748	0.0667
24	14	2	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3120	0.2449	0.0671
24	42	2	100	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2429	0.1744	0.0685
24	28	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.8254	0.7568	0.0686
24	28	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.8254	0.7568	0.0686
24	28	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3135	0.2449	0.0686
24	42	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3472	0.2783	0.0689
24	14	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.1093	1.0388	0.0705
24	28	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3194	0.2449	0.0745
24	42	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3216	0.2449	0.0768

24	28	2	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3575	0.2783	0.0793
24	42	2	50	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.2884	0.2078	0.0806
24	28	2	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3268	0.2449	0.0819
24	42	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3305	0.2449	0.0856
24	42	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3649	0.2783	0.0867
24	42	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.8475	0.7568	0.0908
24	42	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.8475	0.7568	0.0908
24	42	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6401	0.5453	0.0949
24	42	2	100	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3416	0.2449	0.0967
24	14	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2771	1.1798	0.0974
24	14	2	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.1462	1.0388	0.1075
24	42	2	50	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.3871	0.2783	0.1088
24	14	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6107	0.4898	0.1210
24	14	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6107	0.4898	0.1210
24	28	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.1610	1.0388	0.1223
24	14	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6167	0.4898	0.1269
24	14	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6167	0.4898	0.1269
24	14	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.3067	1.1798	0.1269
24	14	2	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6240	0.4898	0.1343
24	14	2	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6240	0.4898	0.1343
24	28	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6270	0.4898	0.1373
24	28	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6270	0.4898	0.1373
24	28	2	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.8993	0.7568	0.1425
24	28	2	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.8993	0.7568	0.1425
24	14	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6015	0.4564	0.1451
24	14	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6015	0.4564	0.1451
24	14	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6044	0.4564	0.1481
24	14	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6044	0.4564	0.1481
24	28	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6388	0.4898	0.1491
24	28	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6388	0.4898	0.1491

24	42	2	10	1.1	2	10000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.5536	0.4043	0.1494
24	14	2	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6081	0.4564	0.1517
24	14	2	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6081	0.4564	0.1517
24	28	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6096	0.4564	0.1532
24	28	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6096	0.4564	0.1532
24	42	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6433	0.4898	0.1535
24	42	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6433	0.4898	0.1535
24	28	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6155	0.4564	0.1591
24	28	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6155	0.4564	0.1591
24	42	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6177	0.4564	0.1614
24	42	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6177	0.4564	0.1614
24	28	2	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6536	0.4898	0.1639
24	28	2	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6536	0.4898	0.1639
24	14	2	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.3436	1.1798	0.1639
24	28	2	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6229	0.4564	0.1665
24	28	2	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6229	0.4564	0.1665
24	42	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6266	0.4564	0.1702
24	42	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6266	0.4564	0.1702
24	42	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6610	0.4898	0.1713
24	42	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6610	0.4898	0.1713
24	42	2	10	1.1	2	5000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6523	0.4748	0.1776
24	28	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.3584	1.1798	0.1787
24	42	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.9362	0.7568	0.1795
24	42	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.9362	0.7568	0.1795
24	42	2	100	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6377	0.4564	0.1813
24	42	2	100	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6377	0.4564	0.1813
24	28	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.2202	1.0388	0.1814
24	42	2	50	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.6832	0.4898	0.1934
24	42	2	50	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	0.6832	0.4898	0.1934
24	42	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.2423	1.0388	0.2036

24	42	2	10	1.1	2	10000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	0.7510	0.5453	0.2058
24	14	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0055	0.7718	0.2338
24	28	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.4176	1.1798	0.2378
24	14	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0115	0.7718	0.2397
24	14	2	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0188	0.7718	0.2471
24	28	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0218	0.7718	0.2501
24	28	2	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.2941	1.0388	0.2553
24	14	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.9963	0.7384	0.2579
24	42	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.4397	1.1798	0.2600
24	14	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	0.9992	0.7384	0.2609
24	28	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0336	0.7718	0.2619
24	14	2	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0029	0.7384	0.2645
24	28	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0044	0.7384	0.2660
24	42	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0381	0.7718	0.2663
24	28	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0103	0.7384	0.2719
24	42	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0125	0.7384	0.2742
24	28	2	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0484	0.7718	0.2767
24	28	2	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0177	0.7384	0.2793
24	42	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0214	0.7384	0.2830
24	42	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0558	0.7718	0.2841
24	14	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2029	0.9128	0.2902
24	42	2	10	1.1	2	5000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0471	0.7568	0.2904
24	42	2	10	1.1	2	10000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.0471	0.7568	0.2904
24	42	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.3310	1.0388	0.2923
24	42	2	100	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0325	0.7384	0.2941
24	14	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2089	0.9128	0.2961
24	14	2	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2162	0.9128	0.3035
24	42	2	50	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.0780	0.7718	0.3062
24	28	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2192	0.9128	0.3065
24	28	2	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.4915	1.1798	0.3117

24	14	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.1937	0.8794	0.3143
24	14	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.1966	0.8794	0.3173
24	28	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2310	0.9128	0.3183
24	14	2	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2003	0.8794	0.3209
24	28	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2018	0.8794	0.3224
24	42	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2355	0.9128	0.3227
24	28	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2077	0.8794	0.3283
24	42	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2099	0.8794	0.3306
24	28	2	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2458	0.9128	0.3331
24	28	2	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2151	0.8794	0.3357
24	42	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2188	0.8794	0.3394
24	42	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2532	0.9128	0.3405
24	42	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.5284	1.1798	0.3487
24	42	2	100	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2299	0.8794	0.3505
24	42	2	50	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.2754	0.9128	0.3626
24	42	2	10	1.1	2	1000	500	1.41	1	0.38	18	3	0.65	3	0.0475	1.4419	1.0388	0.4032
24	42	2	10	1.1	2	5000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	1.6393	1.1798	0.4596
24	14	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0537	2.4488	0.6050
24	14	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0833	2.4488	0.6345
24	14	2	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.1202	2.4488	0.6715
24	28	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.1350	2.4488	0.6863
24	28	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.1942	2.4488	0.7454
24	42	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.2163	2.4488	0.7676
24	14	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9795	2.1818	0.7978
24	14	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9855	2.1818	0.8037
24	14	2	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9928	2.1818	0.8111
24	28	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9958	2.1818	0.8141
24	28	2	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.2681	2.4488	0.8193
24	14	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9703	2.1484	0.8219
24	14	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9732	2.1484	0.8249

24	28	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0076	2.1818	0.8259
24	14	2	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9769	2.1484	0.8285
24	28	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9784	2.1484	0.8300
24	42	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0121	2.1818	0.8303
24	28	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9843	2.1484	0.8359
24	42	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9865	2.1484	0.8382
24	28	2	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0224	2.1818	0.8407
24	28	2	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9917	2.1484	0.8433
24	42	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	2.9954	2.1484	0.8470
24	42	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0298	2.1818	0.8481
24	42	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.3050	2.4488	0.8563
24	42	2	100	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0065	2.1484	0.8581
24	42	2	50	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.0520	2.1818	0.8702
24	42	2	10	1.1	2	1000	1500	1.41	1	0.38	18	3	0.65	3	0.0475	3.4159	2.4488	0.9672
24	14	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.0147	4.5638	1.4510
24	14	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.0443	4.5638	1.4805
24	14	2	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.0812	4.5638	1.5175
24	28	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.0960	4.5638	1.5323
24	28	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.1552	4.5638	1.5914
24	42	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.1773	4.5638	1.6136
24	14	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9405	4.2968	1.6438
24	14	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9465	4.2968	1.6497
24	14	2	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9538	4.2968	1.6571
24	28	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9568	4.2968	1.6601
24	28	2	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.2291	4.5638	1.6653
24	14	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9313	4.2634	1.6679
24	14	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9342	4.2634	1.6709
24	28	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9686	4.2968	1.6719
24	14	2	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9379	4.2634	1.6745
24	28	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9394	4.2634	1.6760

24	42	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9731	4.2968	1.6763
24	28	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9453	4.2634	1.6819
24	42	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9475	4.2634	1.6842
24	28	2	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9834	4.2968	1.6867
24	28	2	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9527	4.2634	1.6893
24	42	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9564	4.2634	1.6930
24	42	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9908	4.2968	1.6941
24	42	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.2660	4.5638	1.7023
24	42	2	100	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	5.9675	4.2634	1.7041
24	42	2	50	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.0130	4.2968	1.7162
24	42	2	10	1.1	2	1000	3000	1.41	1	0.38	18	3	0.65	3	0.0475	6.3769	4.5638	1.8132

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

APPENDIX E

MULTIPLE VARIABLE SIMULATION DATA FOR HIGH COST CONTAINER

UCR	CT	PVF	PQ	CRR	CL	ADV	DD	MR	FOS	TR	LR	UCE	TE	CW	DR	RCSC	ECSC	RCSC-ECSC
400	14	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.4653	6.104	-4.6390
400	14	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.5640	6.174	-4.6108
400	14	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.6627	6.245	-4.5826
400	14	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.9588	6.456	-4.4980
400	14	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.9588	6.456	-4.4980
400	14	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.3536	6.738	-4.3852
400	14	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.5510	6.879	-4.3288
400	14	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.9581	6.104	-4.1462
400	14	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.0568	6.174	-4.1180
400	14	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	2.1555	6.245	-4.0898
400	14	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	2.4516	6.456	-4.0052
400	14	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.4516	6.456	-4.0052
400	14	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.8464	6.738	-3.8924
400	14	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	3.0438	6.879	-3.8360
400	14	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.3276	8.148	-3.8212
400	14	2	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.5741	6.104	-3.5302
400	14	2	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.6728	6.174	-3.5020
400	14	2	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	2.7715	6.245	-3.4738
400	14	2	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.0676	6.456	-3.3892
400	14	2	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	3.0676	6.456	-3.3892
400	14	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.8204	8.148	-3.3284
400	28	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.8205	6.104	-3.2838

400	14	2	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	3.4624	6.738	-3.2764
400	28	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.9192	6.174	-3.2556
400	28	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.0179	6.245	-3.2274
400	14	2	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	3.6598	6.879	-3.2200
400	28	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.3140	6.456	-3.1428
400	28	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	3.3140	6.456	-3.1428
400	28	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	3.7088	6.738	-3.0300
400	14	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	7.2886	10.263	-2.9752
400	28	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	3.9062	6.879	-2.9736
400	14	2	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	5.4364	8.148	-2.7124
400	14	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	7.7814	10.263	-2.4824
400	28	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	5.6828	8.148	-2.4660
400	28	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	3.8061	6.104	-2.2982
400	28	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	3.9048	6.174	-2.2700
400	28	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.0035	6.245	-2.2418
400	28	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.2996	6.456	-2.1572
400	28	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	4.2996	6.456	-2.1572
400	28	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	4.6944	6.738	-2.0444
400	28	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	4.8918	6.879	-1.9880
400	42	1.1	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	4.1757	6.104	-1.9286
400	42	1.1	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	4.2744	6.174	-1.9004
400	42	1.1	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.3731	6.245	-1.8722
400	14	2	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	8.3974	10.263	-1.8664
400	42	1.1	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.6692	6.456	-1.7876
400	42	1.1	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	4.6692	6.456	-1.7876
400	42	1.1	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.0640	6.738	-1.6748
400	28	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	8.6438	10.263	-1.6200
400	42	1.1	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	5.2614	6.879	-1.6184
400	28	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	6.6684	8.148	-1.4804
400	42	1.1	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	7.0380	8.148	-1.1108

400	28	2	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.0381	6.104	-1.0662
400	28	2	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.1368	6.174	-1.0380
400	28	2	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	5.2355	6.245	-1.0098
400	28	2	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	5.5316	6.456	-0.9251
400	28	2	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	5.5316	6.456	-0.9251
400	14	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.3720	1.277	-0.9052
400	14	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4707	1.347	-0.8770
400	14	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5694	1.418	-0.8488
400	28	2	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.9264	6.738	-0.8123
400	14	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4706	1.277	-0.8067
400	14	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5693	1.347	-0.7785
400	14	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8655	1.629	-0.7642
400	14	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.8655	1.629	-0.7642
400	28	2	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1238	6.879	-0.7559
400	14	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6680	1.418	-0.7503
400	14	2	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5938	1.277	-0.6835
400	14	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9641	1.629	-0.6657
400	14	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.9641	1.629	-0.6657
400	14	2	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6925	1.347	-0.6553
400	14	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.2603	1.911	-0.6514
400	28	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	9.6294	10.263	-0.6344
400	28	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6431	1.277	-0.6342
400	14	2	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7912	1.418	-0.6271
400	28	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7418	1.347	-0.6060
400	14	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.4577	2.052	-0.5950
400	28	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8405	1.418	-0.5778
400	14	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3589	1.911	-0.5529
400	14	2	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0873	1.629	-0.5425
400	14	2	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.0873	1.629	-0.5425
400	14	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.5563	2.052	-0.4965

400	28	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1366	1.629	-0.4932
400	28	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.1366	1.629	-0.4932
400	42	1.5	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.6541	6.104	-0.4502
400	14	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.2354	0.673	-0.4385
400	28	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8402	1.277	-0.4371
400	14	2	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.4821	1.911	-0.4297
400	42	1.5	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	5.7528	6.174	-0.4220
400	14	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.3341	0.744	-0.4103
400	28	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9389	1.347	-0.4089
400	42	1.5	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	5.8515	6.245	-0.3938
400	14	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.2846	0.673	-0.3892
400	14	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4328	0.814	-0.3821
400	28	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0376	1.418	-0.3807
400	28	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.5314	1.911	-0.3804
400	14	2	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.6795	2.052	-0.3733
400	42	1.1	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9141	1.277	-0.3632
400	14	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.3833	0.744	-0.3610
400	42	1.1	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0128	1.347	-0.3350
400	14	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4820	0.814	-0.3328
400	14	2	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.3462	0.673	-0.3276
400	28	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.7288	2.052	-0.3240
400	42	1.5	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	6.1476	6.456	-0.3092
400	42	1.5	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1476	6.456	-0.3092
400	42	1.1	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1115	1.418	-0.3068
400	28	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.3709	0.673	-0.3030
400	14	2	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4449	0.744	-0.2994
400	14	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7289	1.026	-0.2975
400	14	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.7289	1.026	-0.2975
400	28	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3337	1.629	-0.2961
400	28	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.3337	1.629	-0.2961

400	28	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4696	0.744	-0.2748
400	14	2	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5436	0.814	-0.2712
400	42	1.1	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	9.9990	10.263	-0.2648
400	28	2	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	7.9004	8.148	-0.2484
400	14	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7781	1.026	-0.2482
400	14	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.7781	1.026	-0.2482
400	28	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5683	0.814	-0.2466
400	42	1.1	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.4076	1.629	-0.2222
400	42	1.1	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.4076	1.629	-0.2222
400	28	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.4694	0.673	-0.2044
400	42	1.5	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	6.5424	6.738	-0.1963
400	28	2	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0866	1.277	-0.1907
400	14	2	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8397	1.026	-0.1866
400	14	2	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.8397	1.026	-0.1866
400	14	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1237	1.308	-0.1847
400	28	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.7285	1.911	-0.1833
400	28	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5681	0.744	-0.1762
400	42	1.1	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5064	0.673	-0.1675
400	28	2	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1853	1.347	-0.1625
400	28	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8644	1.026	-0.1620
400	28	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.8644	1.026	-0.1620
400	28	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6668	0.814	-0.1480
400	42	1.5	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.7398	6.879	-0.1400
400	42	1.1	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6051	0.744	-0.1393
400	14	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1729	1.308	-0.1354
400	28	2	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.2840	1.418	-0.1343
400	14	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.3211	1.449	-0.1283
400	28	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.9259	2.052	-0.1269
400	42	1.1	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7038	0.814	-0.1111
400	42	1.1	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.8024	1.911	-0.1094

400	14	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.2343	3.321	-0.0874
400	28	2	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.5926	0.673	-0.0812
400	14	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.3703	1.449	-0.0790
400	14	2	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.2345	1.308	-0.0738
400	42	1.5	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.2098	1.277	-0.0675
400	28	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9629	1.026	-0.0634
400	28	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.9629	1.026	-0.0634
400	28	2	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6913	0.744	-0.0530
400	42	1.1	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.9998	2.052	-0.0529
400	28	2	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.5801	1.629	-0.0497
400	28	2	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.5801	1.629	-0.0497
400	28	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.2592	1.308	-0.0492
400	42	1.5	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3085	1.347	-0.0393
400	42	1.1	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9999	1.026	-0.0265
400	42	1.1	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	0.9999	1.026	-0.0265
400	28	2	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7900	0.814	-0.0248
400	42	1.5	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.6542	0.673	-0.0196
400	14	2	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.4319	1.449	-0.0174
400	42	1.5	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.4072	1.418	-0.0111
400	28	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.4566	1.449	0.0072
400	42	1.5	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.7529	0.744	0.0086
400	14	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.3329	3.321	0.0111
400	42	1.5	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8516	0.814	0.0368
400	28	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3577	1.308	0.0494
400	28	2	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0861	1.026	0.0598
400	28	2	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.0861	1.026	0.0598
400	28	2	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.9749	1.911	0.0631
400	42	1.5	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.7033	1.629	0.0735
400	42	1.5	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.7033	1.629	0.0735
400	42	1.1	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3947	1.308	0.0863

400	28	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.5551	1.449	0.1058
400	28	2	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.1723	2.052	0.1195
400	42	1.5	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.1477	1.026	0.1214
400	42	1.5	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.1477	1.026	0.1214
400	14	2	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.4561	3.321	0.1343
400	42	1.1	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.5921	1.449	0.1427
400	42	2	100	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.8390	0.673	0.1652
400	28	2	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.4809	1.308	0.1726
400	28	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.5054	3.321	0.1836
400	42	1.5	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.0981	1.911	0.1863
400	42	2	100	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	0.9377	0.744	0.1934
400	42	2	100	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.0364	0.814	0.2216
400	28	2	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.6783	1.449	0.2290
400	42	1.5	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.5425	1.308	0.2342
400	42	1.5	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.2955	2.052	0.2427
400	42	1.5	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.7399	1.449	0.2906
400	42	2	50	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.5794	1.277	0.3021
400	42	2	100	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.3325	1.026	0.3062
400	42	2	100	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.3325	1.026	0.3062
400	42	2	50	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.6781	1.347	0.3303
400	42	2	50	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	1.7768	1.418	0.3585
400	42	1.5	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	8.5164	8.148	0.3676
400	14	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.0977	2.718	0.3793
400	28	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.7025	3.321	0.3807
400	42	2	100	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	1.7273	1.308	0.4190
400	14	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.1469	2.718	0.4286
400	42	2	50	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	2.0729	1.629	0.4431
400	42	2	50	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.0729	1.629	0.4431
400	42	1.1	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.7764	3.321	0.4547
400	42	2	100	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	1.9247	1.449	0.4754

400	14	2	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.2085	2.718	0.4902
400	28	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.2332	2.718	0.5148
400	42	2	50	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	2.4677	1.911	0.5559
400	28	2	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	10.861	10.263	0.5977
400	42	2	50	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	2.6651	2.052	0.6123
400	28	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.3317	2.718	0.6134
400	28	2	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.9489	3.321	0.6271
400	42	1.1	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.3687	2.718	0.6503
400	28	2	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.4549	2.718	0.7366
400	42	1.5	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.0721	3.321	0.7503
400	14	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1953	5.436	0.7586
400	42	1.5	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.5165	2.718	0.7982
400	14	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.2939	5.436	0.8571
400	14	2	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.4171	5.436	0.9803
400	42	2	100	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	3.7013	2.718	0.9830
400	28	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.4664	5.436	1.0296
400	42	2	50	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	4.4417	3.321	1.1199
400	42	1.5	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	11.477	10.263	1.2137
400	14	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.0587	4.833	1.2253
400	28	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.6635	5.436	1.2267
400	14	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1079	4.833	1.2746
400	42	1.1	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.7374	5.436	1.3007
400	14	2	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1695	4.833	1.3362
400	28	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.1942	4.833	1.3608
400	42	2	10	1.1	2	10000	500	1.41	1	0.38	18	60	0.65	3	0.0475	7.5021	6.104	1.3979
400	42	2	10	1.1	2	5000	500	1.41	1	0.38	18	60	0.65	3	0.0475	7.6008	6.174	1.4261
400	42	2	10	1.1	2	10000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	7.6995	6.245	1.4543
400	28	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.2927	4.833	1.4594
400	28	2	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.9099	5.436	1.4731
400	42	1.1	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.3297	4.833	1.4963

400	42	2	10	1.1	2	5000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	7.9956	6.456	1.5389
400	42	2	10	1.1	2	10000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	7.9956	6.456	1.5389
400	28	2	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.4159	4.833	1.5826
400	42	1.5	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	7.0331	5.436	1.5963
400	42	1.5	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.4775	4.833	1.6442
400	42	2	10	1.1	2	1000	500	1.41	1	0.38	18	60	0.65	3	0.0475	8.3904	6.738	1.6517
400	42	2	10	1.1	2	5000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	8.5878	6.879	1.7081
400	42	2	100	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	6.6623	4.833	1.8290
400	42	2	50	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	7.4027	5.436	1.9659
400	42	2	10	1.1	2	1000	1500	1.41	1	0.38	18	60	0.65	3	0.0475	10.364	8.148	2.2157
400	42	2	10	1.1	2	1000	3000	1.41	1	0.38	18	60	0.65	3	0.0475	13.325	10.263	3.0617

UCR: unit cost of returnable container, $/container
PVF: peak volume factor
CRR: container replenishment rate
ADV: average daily usage, parts/day
MR: mileage rate, $/mile
TR: time needed to handle returnable containers, minutes/container
UCE: unit cost of expendable container, $/container

CW: container weight, lbs/container
RCSC: returnable container system cost, $/part

CT: cycle time, days
PQ: pack quantity, parts/container
CL: container life, years
DD: delivery distance, miles
FOS: frequency of supply, days
LR: labor rate, $/hour
TE: time needed to handle expendable container, minutes/container
DR: disposal rate per lbs, $/lbs
ECSC: expendable container system cost, $/part

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