The Effect of Pallets and Unitization on the Efficiency of Intercontinental Product Movement Using Ocean Freight Containers

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ABSTRACT

Global industrialization was developed in response to both consumers and manufacturers demand for lower product prices and availability of goods and services. As a result, products are transported greater distances. Shipping constitutes the majority of costs in the export/import supply chain. Shippers and buyers commonly attempt to offset these costs by maximizing the capacity of ocean freight containers (cube or weight). Boxes (usually constructed of corrugated fiberboard) containing consumer grade products are commonly floor loaded into containers to maximize capacity. Boxes that are not floor loaded are likely to be unitized on pallets in containers. Beyond maximizing a container with cargo, a defined decision to determine which method of loading is most efficient in regard to cost and time does not exist. For this research, field studies were conducted and questionnaires were distributed to identify the variables that influence efficiency. A method to make an efficient decision was developed by incorporating the variables into a model. The model compares the overall export/import supply chain efficiency for boxes that are floor loaded to boxes that are unitized on pallets in containers. The recommended decision is determined by comparing the shipping and handling costs and the receiving dock door capability for the two loading methods.

The results of this research reveal that floor loading boxes can provide a higher value per container due to increased capacity. Increased capacity by floor loading often reduces the number of containers needed to meet daily demand. However, since manual labor is utilized for the loading/unloading process, more time is required, which results in higher labor costs and

restricted product throughput. Unitized boxes loaded in containers on pallets can limit container capacity, but allows for faster loading/unloading times (if no incompatibilities between product and pallet or pallet and/or material handling equipment exist), reduced labor costs, and the potential for increased product throughput. Importing boxes unitized on pallets commonly requires more containers to meet demand, but fewer receiving dock doors. Utilizing fewer dock doors allows otherwise occupied doors to be available to receive additional product.

The decision to floor load or unitize exports/imports needs to be made on a SKU basis meeting daily demand, not only per container capacity. Labor cost, pallet cost, the magnitude of box variation between loading methods, and the ability of the receiver to process containers are all influencing factors in determining which loading method is most overall efficient. Given the current cost for containerized shipments and considering all costs, most consumer goods are more efficiently shipped floor loaded. When additional containers would be needed to meet demand for product unitized on pallets, floor loading will be more efficient. When there is only a small difference in box count between floor loading and palletizing, palletizing product will be more efficient. This will often occur when loads will meet container weight capacity before it reaches volume capacity. If the product is too heavy to move manually it will be palletized.

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CHAPTER 1. INTRODUCTION

1.1 Introductory Statement

Intercontinental trade has grown rapidly through the creation and utilization of freight containers. Containerization allows for mass quantities of goods to be transported long distances safely, efficiently, and at low costs. Initially, containers were introduced to reduce the cost and time associated with loading and unloading cargo from ships (Donovan & Bonney, 2006). Containerships are estimated to be 17 times more fuel efficient than transferring goods by air and 10 times more fuel efficient than transferring goods by truck (World Shipping Council, 2008). Containers provide efficient access to raw materials and reduced manufacturing and labor costs. The benefits of utilizing containers have caused an increase in the demand for freight containers. According to the World Shipping Council (2006), container trade increased an average of 11 percent per year from 2000 to 2006. A projection made in 2006 predicted container trade would reach 600,000 per day by year 2014 (World Shipping Council, 2006).

Like containers, the pallet is used as a medium to efficiently transfer product from one location to another. Pallets allow assembled quantities of unitized products to be handled and transported on a single platform. The pallet was developed to move more products more efficiently and more cost effectively (AIM Position Paper, 2005). Forklift handling of pallets reduces the labor cost and time needed to handle and distribute products (Twede & Selke, 2000).

The World Shipping Council (2006) reported that imports and exports arrive and depart the United States from 116 ports. Ten of the 116 ports handle 85 percent of trade volume. Future projections suggest that freight volume will double by 2020. The U.S. infrastructure is not capable of handling the expected increases without capacity expansion modifications (World Shipping Council, 2006). Thus, projected increases in trade will force global manufacturers, shippers, receivers, and buyers to work more efficiently. Using pallets to reduce the amount of time to load/unload product in containers can allow increased throughput, but may also require the use of more containers. When an inbound floor loaded container arrives at an import distribution center (IDC) or a third party logistics provider (3PL) and cannot be readily unloaded, time is lost. Through research it was found that containerships often arrive simultaneously. Unloading product when it arrives all at once can be problematic, especially since IDC and 3PL facilities have a fixed number of receiving dock doors. As current supply chains are nearing capacity, time is becoming more critical, not only to meet demand, but also to keep costs low to customers. Increases in product shipments will create bottlenecks at receiving dock doors. Product will need to be unloaded and stored at much faster rates.

Ocean shipping costs constitute the majority of costs associated with distributing product internationally. Because of this, manufacturers, shippers, and buyers are faced with the dilemma of having to decide whether to ship boxed products floor loaded or unitized on pallets in containers. It is often assumed, regardless of the method of loading/unloading, that the IDC or 3PL will be able to meet the desired product demand. By floor loading, there is potential to obtain a higher box count per container. This can result in a higher product value per container. Shipping boxes unitized on pallets allows more efficient loading/unloading and can exceed the value of boxes floor loaded in containers per day. Several computer programs have been developed to evaluate box count and cube efficiency for containers, railcars, and/or trailers, but none evaluate how product should be loaded in relation to costs and time.

1.2 Statement of the Need

Boxes unitized on pallets are easily handled, stored, and distributed. However, through research, field studies, and questionnaires it was found that many consumer boxed products imported into the U.S.A. arriving in containers to IDC and 3PL facilities are more likely to be floor loaded than loaded on pallets. The criteria to determine if boxed products should be floor loaded or unitized in containers is vague and can vary from location to location and product to product. Boxed products are floor loaded to maximize the container cube or allowable container weight to obtain a higher product value per container, due to the added capacity. Pallets occupy space and add weight in containers that could otherwise be occupied by product. An initial cost (pallet cost) exists by exporting boxed products on pallets. An additional cost (phytosanitation cost) is incurred if the export pallet is constructed from wood. Boxes floor loaded in containers take longer to unload than if unitized, which results a higher overall labor cost. Commonly, floor loaded boxes are offloaded from containers onto pallets at IDC and 3PL facilities.

IDC and 3PL facilities have a fixed number of receiving dock doors. Containers parked at dock doors prohibit other containers from accessing the doors, unless ample receiving dock doors exist. Previous studies predict that the current infrastructure is not capable of handling projected container traffic (World Shipping Council, 2006). IDC and 3PL facilities will need to respond to increased container traffic in order to meet increased product demand. Due to the additional time required to unload floor loaded boxes, throughput is restricted. According to the president of a 3PL, container cargo must be unloaded within two hours to avoid additional charges. Unlike boxes unitized on pallets, it is unlikely that floor loaded boxes can be unloaded in the allotted two hour time frame, and the container must be left at the facility until it can be unloaded (President 3PL, personal communication, 2009).

A methodology was needed to aid manufacturers, shippers, buyers, and receivers to optimize the decision to export/import boxes floor loaded or unitized on pallets in containers.

1.3 Objectives

The purpose of this research was to determine which container cargo loading method is more efficient in relation to cost and time for intercontinental product movement. The objectives of this research were to:

- Determine container cargo loading methods for boxed products received at IDC and 3PL facilities.
- Evaluate and compare the cost and time characteristics of the two container cargo loading methods for boxed products.
- Develop a decision methodology to determine the optimal loading method for boxed products based on a defined set of decision variables.

1.4 Scope

Supply chains can be variable and highly complex. However, most exports shipped in containers conform to the sequence depicted in Figure 1-1. Removing pre-loading and post unloading operations focuses the research specifically to export and import operations. Boxed products are classified as being able to be handled by one or two individuals and can fit on common pallet sizes. For this research, pallet size was assumed to be compatible with the product, all handling equipment, and storage facilities.

The loading operation consists of floor loading boxes in containers, or loading unit loads of boxes in containers. Export drayage is the transport of the container via truck and chassis to the port from a manufacturing, IDC, or 3PL facility. The shipping process involves receiving containers at a port, loading on ship, shipping to destined location, and offloading. Import drayage is the transport of the container via truck and chassis from the port to an IDC or 3PL facility. The unloading operation consists of removing floor loaded boxes from containers and placing on pallets, or removing unit loads from containers using a forklift. Data collection targeted the highest volume products imported into select IDC and 3PL facilities. Focusing only on the highest volume import per location provided specific information about product attributes and associated costs and time.

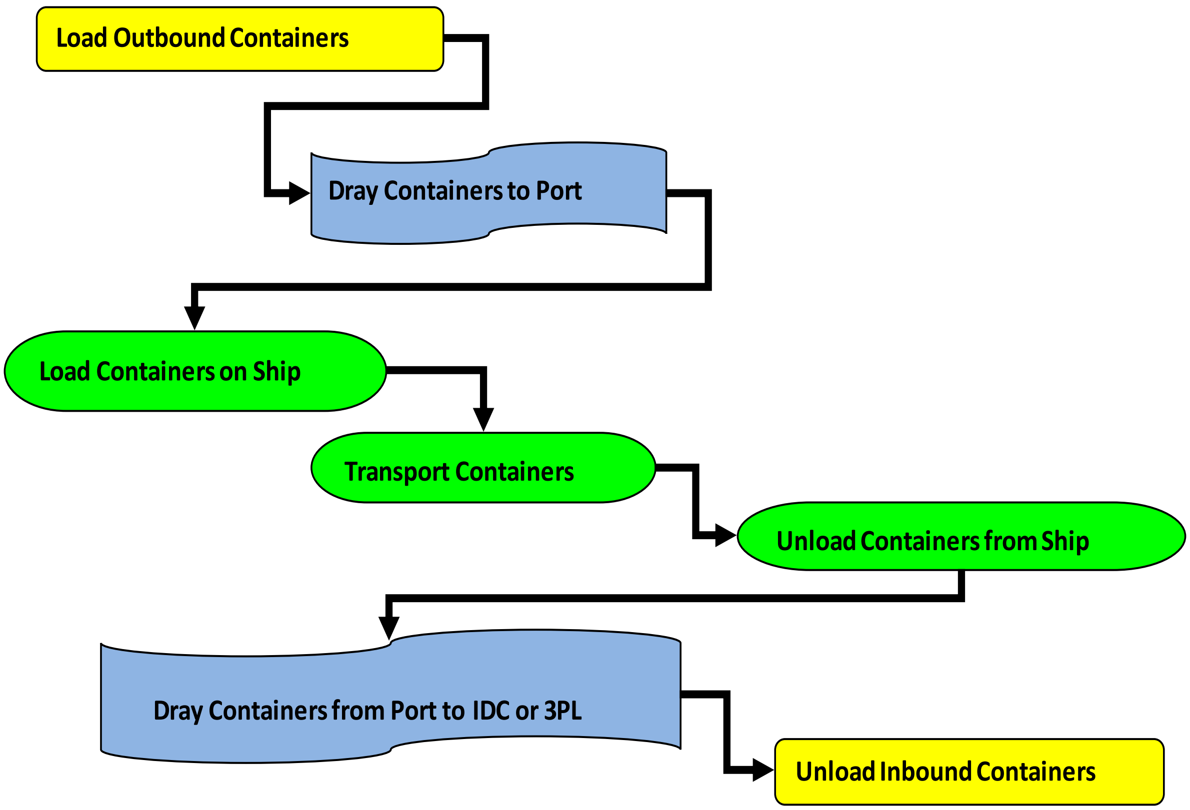

Figure 1-1 Export/Import Supply Chain

1.5 Statement of the Limitations

Due to accessibility, field studies and the majority of the sample frame were obtained from Virginia and surrounding regions. Access to IDC and 3PL facilities either through field studies or a questionnaire was limited. For some facilities, data regarding product information and costs is confidential and not easily obtainable. Some respondents did reveal information considered confidential. IDC and 3PL facilities commonly handle an array of products from different sources for various customers. To obtain specific product information, and specific information regarding costs and time, this research focused on highest volume product received at IDC and 3PL facilities. The highest volume product received can constitute only a small percentage of total import products received. Since data was not collected from overseas exporters, assumptions were made to demonstrate the application of the model.

CHAPTER 2. LITERATURE REVIEW

2.1 Containerized Shipping Industry

Imports have grown at overwhelming rates causing congestion and concern for U.S. ports and infrastructure. A continued increase of container shipments of nine to ten percent per year was expected ("Editorial Staff SCD," 2007). Because of the increase of shipments, the size of new containerships has increased. Future containership sizes are predicted to be able to transport 15,000 twenty foot equivalent units (TEUs) in one shipment (classified as a mega ship) (Rich, 2006). Container shipment predictions were revised as the trend began to reverse in late 2007 ("Editorial Staff SCD," 2007). Fuel prices hit record highs in 2008, followed by an economic crisis. The increase in fuel prices resulted in an increase in shipping charges, as fuel constitutes 50-60% of shipping costs (World Shipping Council, 2008). Due to the high shipping costs, overseas manufacturers have considered relocating facilities to offset the cost (Aeppel, 2008). Shipping charges can be offset by maximizing the container cube or weight of the container. By doing so, fewer container shipments are needed.

Bonney (2009) reported that trade activity had declined. As a result, approximately 200 less containerships were needed. Projected container shipments were revised, but not before ship construction projects to meet the increased demand projections neared completion. An additional 100 containerships are expected in the next two years. The decrease in demand caused otherwise occupied space on containerships to be vacant, resulting in reduced shipping costs (Bonney, 2009). However, Maersk, the largest ship line announced it was necessary to increase shipping rates by $300 and implement an additional $150 surcharge on select routes due to trade conditions (Attwood, 2009). Container shipment volumes of imports have again begun to increase month to month, but still remain down 16% to 21% compared to 2008 (Mongelluzzo, 2009).

2.1.1 Standard Container Sizes

An array of container sizes existed during the late 1950's. Varying container sizes and ship sizes were problematic in regards to ships and handling equipment (cranes) (Levinson, 2006). The International Organization for Standardization (ISO) has since published a standard on container sizes. The current standard consists of three container sizes (20', 40', and a 40' high cube (HC)). The external length, width, and height of the ISO containers are shown in Table 2-1 (Hinkelman, 2005). The container standard allowed compatibility for overland transport modes (Levinson, 2006).

Table 2-1 External Standard Container Sizes

External Dimensions	20'	40'	40' HC
Outside Length	20'	40'	40'
Outside Width	8'	8'	8'
Outside Height	8'6	8'6	9'6

Even though standard container sizes were created by ISO, some variations still exist. Depending on the container construction, the internal dimensions are variable. An example of internal dimensions for 20', 40', and 40' HC are displayed in Table 2-2 (Hinkelman, 2005).

Table 2-2 Internal Standard Container Dimensions Example

Internal Dimensions	20'	40'	40' HC
Inside Length	19' 4 "	39' 5 3/8 "	39' 5 3/8 "
Inside Width	7' 8 1/2"	7' 8 1/2"	7' 8 1/2"
Inside Height	7' 9 7/8"	7' 10"	8' 10 1/8"

Supply and Demand Chain Exclusive (2007) reported that 53' containers were introduced in 2007 by APL ship lines. APL's 53' containers are 9 feet 6 inches high and 102 inches wide. Utilizing 53' containers allow more cargo and fewer shipments ("Editorial Staff SDCE," 2007).

2.1.2 Container Weight Restrictions

The construction of the container has an influence on maximum allowable gross weights (container tare weight plus weight of contents). According to ISO 688, the maximum gross weight for a 20' container is 24,000 kilograms (52,910 pounds) and 30,480 kilograms (67,200 pounds) for a 40' container (Hinkelman, 2005). Through dialogue with a 3PL president (2009), it was found that steamship or vessel lines may dictate the weight restriction further, regardless of what the container states (President 3PL, personal communication, 2009). A Senior Vice President of a major ship line (2009) revealed that most states in the U.S. have an 80,000 pound gross highway weight limit, with the exception of Florida, which has a limitation of 65,000 pounds for a 20' container and 79,000 pounds for a 40' container. The weights include: the weight of the truck, container, chassis, and cargo. Determining allowable container weights is complex as states regulate cargo weight. Depending on individual state regulations, overweight permits may be needed, even though gross vehicle weight is less than 80,000 pounds. Variability of scales along highway runs exists, transporters should be aware of such circumstances (Senior Vice President Ship Line, personal communication, 2009). Depending on the type of truck pulling the container, an empty 40' container and truck averages around 35,000-36,000 lbs, which leaves 45,000 lbs. for cargo (President 3PL, personal communication, 2009). The efficiency of transport is influenced by maximizing the capacity of the transport mode (Ebeling, 1990).

2.1.3 Container Cargo Payment and Responsibility

Hinkelman (2005) lists many different options for payment and responsibility of exports and imports between the seller and buyer. The process is complex, and a variety of options can exist, depending on the agreement made. Simplifying the options to what the buyer is responsible for is defined by the following characteristics:

- The buyer of the product is responsible for the product at the point it leaves the sellers facility (export documentation, drayage exporter, port and shipping charges (export and import port), import documentation, and drayage importer).
- The buyer is responsible for the product once arriving at export port or next to transport ship.
- The buyer is responsible for product after loaded on ship.
- The buyer is responsible once container is offloaded from ship.
- The buyer has no responsibility; the seller is responsible for all costs until container reaches location specified by the buyer (Hinkelman, 2005).

2.2 Container Cargo Loading Methods

Boxed products are commonly floor loaded in containers or loaded into containers on pallets. Figure 2-1 illustrates two different floor loaded containers. Figure 2-2 illustrates boxes unitized on pallets in a container. A study conducted by Sahling, Maltz, & Speh (2007) found that imported product from China was likely to be floor loaded; however, some imports were on pallets. Pallets arriving from China were deemed to be of poor quality (Sahling et al., 2007).

Figure 2-1 Boxes Floor Loaded in a Container

Figure 2-2 Boxes Unitized on Pallets in a Container

2.2.1 Floor Loading

According to Brindley and LeBlanc (2004), floor loading is commonly used for imports into the United States. Furthermore, a representative from Wal-Mart and JC Penny also stated that pallets are not primarily used for imported product (Brindley & LeBlanc, 2004). Cooke (2004) reported the decision of Target to open an import distribution center on the east coast. The facility has 137 dock doors and is comprised of 190 full time employees plus seasonal labor. Imported floor loaded products are manually placed on pallets upon arrival. Outbound trailers are floor loaded (Cooke, 2004). Piasecki (2008) noted that floor loading requires the most labor. When floor loading, considerations should be given to box strength and ensuring the container is clean and dry (Piasecki, 2008). The deciding factors to floor load or palletize is a shipper and SKU based decision (Brindley & LeBlanc, 2004). Moore (2009) revealed that floor loading is often utilized because pallets add weight, a cost, and consume space in transport modes. Products take longer to load and unload floor loaded, which results in an additional labor cost. The additional cost of using manual labor is generally less than the freight savings (Moore, 2009).

2.2.2 Palletization

Pallets are defined by the Encyclopedia of Packaging Technology as "a fabricated platform used as a base for assembling, storing, handling, and transporting materials and products in a unit load" (Bakker & Eckroth 1986, p. 493). According to Ebeling (1990), the considerations of using pallets should include compatibility with handling equipment and the mode of transport. A benefit of using pallets is that pallets reduce the likelihood of product damage through distribution and handling (Ebeling, 1990). Pallets also provide protection to products during shipment from shocks, vibration, and impacts (White, 2000).

Pallets were introduced in the 1930's and gained popularity throughout WWII and thereafter (Bakker & Eckroth, 1986). Due to the increased efficiency of using pallets, the amount of time needed to unload a railcar was reduced from three days to four hours (LeBlanc & Richardson, 2003). Ebeling (1990) offers another example that shows the efficiency per worker hour to increase drastically by utilizing pallets and unit loads. This example portrays a worker being able to move the equivalent of 8 pallets or 480 boxes (dimensions of 18” x 12” x 7.5” weight of 22 lbs) manually per hour, compared to mechanical handling which can move 50 pallets or 3000 boxes per worker hour (Ebeling, 1990).

According to Mulcahy (1998), pallets vary in material, style, and size. Often, the type of application the pallet is used for will determine which material, style, and size should be used. Materials used for manufacturing pallets include: wood, wood based (corrugated), various plastics, metal, as well as combinations and/or composites. Pallets are most commonly constructed of wood (Mulcahy, 1998). White (2000) stated that more than 90 percent of pallets are manufactured from wood.

Smith, et al (2004) conducted a survey to determine if the phytosanitation regulation would deter the use of wood pallets for export. Import and export pallets manufactured from wood are required to be in compliance with “Guidelines for Regulating Wood Packaging Material in International Trade” (ISPM 15). An additional pallet cost exists to be in compliance with ISPM-15. The results from the survey indicated that respondents using wood will continue to use wood for export pallets. Strength and price were provided as influencing factors of material selection (Smith et al., 2004).

The most common pallet designs are as follows: block (true four-way), leg, solid or slave, stringer (partial four-way), and flue (Mulcahy, 1998). According to White (2000), four-way pallets are the best choice for international shipments. Using a four-way pallet allows access on both ends and sides for all forked equipment (White, 2000). Pallets are available in two types, limited use or reusable. Often reusable pallets are part of a pallet pool or pallet exchange program. In a pallet pool/exchange program, the pallets are repaired if needed and reused.

Clarke (2004) revealed pallet rank and pallet application as of 2000. Table 2-3 displays Clarke's information for U.S. pallets. Clarke also provided pallet sizes used globally (Clarke, 2004). Table 2-4 lists the major global pallet sizes. The 1200mm x 1000mm pallet is compatible with warehouses and distribution centers in the United States; the 1100mm x 1100mm is not (White, 2004).

Table 2-3 Pallet Size, Rank, and Application

Pallet Size, L x W 1986	Percent Usage 1986	Pallet Rank 2000	Pallet Application 2000
48" x 40"	28.5%,	48" x 40"	Grocery,
48" x 42"	3.2%,	42" x 42"	Telecommunications, Paint
48" x 48"	4.2%	48" x 48"	Drums
40" x 48"	4.8%	40" x 48"	DOD, Cement
N/A	N/A	48" x 42"	Chemical, Beverage
40" x 40"	2.9%	40" x 40"	Dairy
42" x 42"	5.4%	N/A	N/A
44" x 44"	1.3%	44" x 44"	Drums, Chemical
36" x 36"	2.2%	36" x 36"	Beverage
48" x 36"	1.3%	48" x 36"	Beverage, Paper stock
36" x 48	2.45%	N/A	N/A
48" x 45"	N/A	48" x 45"	Automotive

Table 2-4 Global Pallet Sizes recognized by ISO

World Region	Size in Millimeters	Size in Inches
Europe, Asia	1200 x 1000	47.24 x 39.37
Europe	1200 x 800	47.24 x 31.50
North America	1219 x 1016	48 x 40
Australia	1140 x 1140	44.88 x 44.88
Asia	1100 x 1100	43.30 x 43.30
North America, Europe & Asia	1067 x 1067	42 x 42

Shin, White, and Han (2007) developed a model to compare costs associated with different pallet sizes. For products that do not completely utilize the pallet deck, considerations should be made to use a pallet compatible with destined supply chain. Influencing factors to determine cost follows:

- Pallet purchase cost
- Disposal cost
- Revenue of reusable pallet
- Transport cost
- Warehousing costs

Transport costs considered:

- Inland transportation costs
- Terminal handling charge
- Freight transport cost
- Maximum loading weight
- Floor area utilization for the pallet size (Shin et al., 2007)

2.2.3 Combined Shipping

Wong, Chow, and Sculli (2006) developed a mathematical model to assist with container loading to minimize costs. Associated costs with transporting containers are provided as a shipping line charge, container haulage charge, and the terminal-handling charge. Multiple shipper use of container is considered. Figure 2-3 and 2-4 were created to display the findings. The first shipper visited, referred to as the "head load" has priority. If additional shippers exist and container space is available, products will be filled in allotted space. "Mid load" refers to the second shipper, and "tail load" is the last shipper (Wong, et al., 2006).

Third shipper, if space available	Second shipper, if space available	First shipper visited, highest priority	Container Front

Figure 2-3 Primary Placement of Cargo

If space is not available in the container to accommodate products from other shippers, precedence will be given to those in proceeding containers as shown in Figure 2-5 (Wong, et al., 2006).

Third shipper if space available	Second shipper	Second shipper	Container Front

Figure 2-4 Secondary Placement of Cargo

2.3 Container Shipping Process

Research conducted by Sahling, Maltz, and Speh (2007) describes the sequence of events involved with the container shipping process as:

1. Containership call on terminal at port
2. Longshoreman unload containers using fixed or mobile gantry cranes
3. Containers are either stacked or immediately placed on a truck chassis/rail
4. Once cleared by customs, drayage companies transport the container to a warehouse or yard

The study also emphasizes the impact of uncertainty. Often containerships will make multiple stops. Delays from factors such as weather often cause simultaneous ship arrivals

(Sahling et al., 2007). Ship turnaround time is the most important performance measure for port terminals (Murty, Liu, Wan, & Linn, 2005). The goal is to minimize the time to load/unload containers from ships. This measure incorporates the rate of the crane as follows:

$$\text{QC (quay cranes) rate} = \frac{\text{Number of containers unloaded, loaded}}{\text{Total number of QC hours of all QCs that worked}}$$ (Murty, et al., 2005)

2.4 Drayage: Live Load/Unload or Drop

Distributing containers from an export facility to the port or from the port to an import facility is termed drayage. Documentation from a president of a 3PL warehouse (2009) revealed once containers are drayed to an IDC or 3PL facility, one of two scenarios occurs. In the first scenario, containers are either loaded or unloaded immediately. This is known as a “live load” or a “live unload.” In a live load/unload, the truck driver will wait for the product to be loaded or unloaded, and then take the container. Generally, two hours is allowed. If the product cannot be loaded or unloaded in the allotted time, a detention charge will be applied. The charge can range from $70-$90 per hour. In the second scenario, the container and chassis is dropped for loading/unloading the product. This is known as dropping the container. Generally, three to five free days are allotted for this instance. As long as product can be loaded or unloaded in the free days, no additional charge is acquired. Figure 2-5 is a dropped container (President 3PL, personal communication, 2009).

Figure 2-5 Drop Container

2.5 Import Warehousing

Once imported product reaches the country of destination, IDCs and 3PLs are used for a number of purposes. Bartholdi and Hackman (2007) use Target and Wal-Mart as examples to define a retail distribution center. High volumes of product are received and distributed to many retail locations. IDCs have similar functions; however product may be either transferred to retail distribution centers or the retailer. 3PL facilities commonly do not serve a single retail customer, but an array of customers (Bartholdi & Hackman, 2007). Supply Chain Digest (2007) reported the functions and expectations of import warehouses. The functions and expectations include: transloading, distribution, warehousing, and postponement. Transloading involves transferring contents from a container into a highway trailer or railcar. In distribution, products are sorted and prepared for the next destination. Warehousing involves storing products until needed. Postponement includes performing value added services to products ("Editorial Staff SCD," 2007).

Recommendations by were made to minimize bottlenecks at import distribution centers. Recommendations include: having a better understanding of import arrivals, flexibility of container pickup, and access to temporary workers for demand variations **(**"Editorial Staff SCD," 2007). When product arrives to port, containers must be processed in accordance to the agreement made; otherwise additional charges will be applied. Since facilities have a fixed number of receiving dock doors, getting product in when it arrives simultaneously can be problematic.

2.5.1 Receiving Dock Doors

Dock doors are an initial layout design consideration. Warehouses handling minimal volume can share the same shipping and receiving area; however, warehouses intended for cross docking should use separate doors (Mulcahy, 1999). Bartholdi and Gue (2004) provide a method to determine how many receiving dock doors are needed. The number of trailers and the unloading time are important factors. An estimated number of receiving doors can be obtained by multiplying the expected number of trailers by the average time needed to unload a trailer (Bartholdi & Gue, 2004).

2.5.2 Material Handling Equipment

Material handling equipment allows products to be moved with minimal manual labor. Handling equipment is required to move unit loads of product, due to the weight. Pallets allow for "efficient loading, unloading, and delivery at any point where standard hand-jacks or forklift equipment are located" (LeBlanc & Richardson, 2003, p. 2). The most common equipment used to unload, load, or transfer unitized boxes on pallets in a warehouse facility are pallet jacks and forklifts. Various versions of the equipment exist. According to Mulcahy (1998), the load and lift mechanism should influence the decision. Forklifts differ from pallet jacks in that multiple unit loads can be transferred at one time, with the capability to lift the load high into or out of storage in a warehouse (Mulcahy, 1998).

CHAPTER 3. METHODOLOGY

3.1 Methods to Meet Objectives

The primary objective of this research was to develop a decision methodology model to determine the most efficient (cost and time) loading method for boxed products based on a defined set of decision variables. To complete the model and meet secondary objectives, it was necessary to understand the operations within the shipping industry and in IDCs and 3PLs. An understanding of the industries was achieved through field studies. Data collected at field studies aided in the development of a questionnaire.

3.2 Field Studies

Field studies were conducted at a port, three IDCs and three 3PLs. These studies consisted of interviewing managerial employees, randomly observing the unloading of containers to determine how various types of products were loaded, and collecting data on product and warehouse attributes. These studies provided an understanding of the operations, as well as a determination of obtainable and pertinent data. Field studies also provided a basis to collect specific information regarding highest volume imports.

3.2.1 Port Field Study

The shipping process and how containers arrive at destined locations begins at the ports. Due to the advanced technology of having the largest reach crane in the United States (26 containers wide) and the ability to handle the megaship, an onsite study was completed at Virginia Port Authority. To gain an understanding of the shipping process, a port tour and an interview were conducted with the port director of business analysis and strategy and the media relations manager.

3.2.2 Results of Port Field Study

The function of the port is to unload freight and freight containers from ships at berth. Products are not unloaded from containers at the port. Ports serve as a distributor of freight. The majority of freight arriving at port is containerized. Once a ship arrives, it is important that the unloading process is completed quickly. Timely unloading is necessary due to the following:

- Costly ship operation, especially at berth
- Meeting demand: ships can be at sea for months, once the ship arrives to the United States, it may take several additional weeks for the ship to arrive at the destined port because many stops can be expected while the ship offloads and loads containers at various locations

Crane operators have a goal of unloading 45 containers an hour. The average unloading rate was 35-38 containers an hour. Upon ship arrival, containers are offloaded onto a truck chassis or railcar, security screened and/or sent to storage for a later pickup date. Once unloaded, several charges may be applied, including additional moves, chassis rental and storage (Director of business analysis and strategy and media relations manager, 2008).

Shipping rates and port charges were not obtainable during the port visit. Shipping rate information was collected from a senior vice president of a major ship line agency. The average shipping rates for the specific ship line for imports into the Unites States was $1,500 for 20' containers and $3,000 for 40'containers at the time of this study. Even though the price to ship and handle containers fluctuates, most exporters and importers are on contract. Contracts generally range from six months to one year. The shipping agency revealed that under a lump sum container rate, the weight or contents are irrelevant to the charge, and often port charges are included in the shipping charge. Heavier container weight does cost more fuel to be burned moving at sea, but is usually offset by the mix of lighter cargo in other containers. (Senior Vice President, personal communication, 2009) Containers are commonly drayed to IDCs and 3PLs upon exiting the port.

3.2.3 IDC & 3PL Field Studies

The only time a container is opened prior to arrival at an IDC or 3PL facility is if containers are inspected prior to leaving a port. Information about the product, and which loading method was used cannot be obtained at this point. Once a loaded container leaves its point of origin, the first opportunity to view and obtain information about the container contents is when the seal is cut at an IDC or 3PL facility. For this research, it was not feasible to obtain information about container cargo and cargo loading methods from overseas exporters. Thus, the first opportunity to obtain accurate container cargo information was at IDC and 3PL facilities.

As products are dispersed within individual supply chains, it becomes difficult to obtain information about how products were loaded into containers, due to alterations of the arrival state of products. Alterations to product arrival include:

- Floor loaded boxes are floor loaded into an outbound trailer
- Floor loaded boxes are palletized with same SKU products or mixed with different SKU products, and either are stored or loaded into an outbound trailer
- Unit loads are loaded into an outbound trailer
- Unit loads are de-palletized and re-palletized due to pallet damage, size incompatibilities, or to change product or pallet configuration
- Unit loads are stored, then dismantled and floor loaded into an outbound trailer

These changes may occur several times throughout the entire supply chain before the product reaches its final destination. Receivers of imported product downstream are often unaware of how products arrive in containers to IDC or 3PL facilities.

In order to protect confidentiality, IDC and 3PL names and locations will not be disclosed. Access to six facilities (three IDCs and three 3PLs) was obtained. Five of the six field study locations were recommended by various port officials.

3.2.4 IDC & 3PL Field Study One

The first field study was conducted at a 3PL export distributer of frozen foods. At this location domestic boxed products arrive to the facility palletized. The boxes are de-palletized and then re-palletized to add separator sheets between product layers. The use of separator sheets allows air flow between box layers in the blast freezer. Once removed from the freezer, all boxes are de-palletized again and floor loaded into an outbound 40’ refrigerated (reefer) container. The general manager (2008) indicated that labor to complete this task consists of three people and takes three work hours (nine man hours) at $15 an hour each ($135 total). It is important to note that a percentage of this product is purchased by the U.S. military. Boxes destined for the military are shipped unitized on pallets. It was also noted that floor loaded product costs more to handle than unitized boxes sent to the military. (General Manager, personal communication, 2008)

3.2.5 IDC & 3PL Field Study Two

The second field study was performed at an import 3PL that primarily handles low value canned goods and other dry food products. Interviewing the assistant general manager (2008) revealed that the majority of imported products are floor loaded in either 20’ or 40’containers. Labor costs per individual to unload imported floor loaded product was $15.00 an hour including benefits. On average, it takes two employees six to eight work hours (12 to 16 man hours, $180 to $240 total) to unload and palletize 3,500 floor loaded boxes from a 40'container. Two employees unloading floor loaded boxes from a container are expected to unload an average of 500 boxes an hour. Once the product is unloaded, it is palletized, stored, or loaded into an outbound trailer in unitized form. Occasionally, the same product arrives in unit load form. In this case, 45 minutes is sufficient time to unload the container. When the product arrives unitized, the labor cost to unload the container increases by one or two dollars per hour, although less time is necessary for the unloading operation. At this field study location, floor loading was preferred, especially for small boxes for the following reasons:

- Additional product per container compared to unitized
- Unitized product often has to be de-palletized and re-palletized because the shipper has built the pallet configuration to the wrong specifications.
- When unit loads arrive in containers, the pallet is often damaged, or is incompatible in size. This results in the product needing to be de-palletized and then re-palletized.

It was noted that some contents of containers are supposed to arrive unitized on pallets, but arrive floor loaded. (Assistant General Manager, personal communication, 2008)

3.2.6 IDC & 3PL Field Study Three

The third field study was conducted at an IDC facility, which imported products for consumer/industrial construction and remodeling. At this location, nearly all imported products are floor loaded. The reasons given by the operations manager (2008) were to maximize the container cube, allow flexibility in building own pallet configuration, and provides a higher container value. Occasionally, some heavy and awkward shaped products arrive on pallets, while others are floor loaded (240 pound boxes) in the container. Products of this nature constitute a small portion of total products.

A lumper service (paid by the container, not the hour, regardless of container contents or time to unload) generally consists of two individuals to unload the floor loaded boxes from containers. The lumper service charge was $118 per 40’ container. Most products are imported in 40’ containers. However; 20’, 40’ HC, and 45’ containers are also utilized. Labor cost to unload 20’ and 45’ containers was $75 and $120, respectively, regardless of contents. Floor loaded boxes received at this facility required pallets to offload products. During a period of five months, the cost of pallets at the facility was $867,800. Pallets cost $8.00 each.

Unloading time requirements range from one to seven work hours. The variability in time was influenced by the product, the number of SKUs per container, and the container size. A time sheet of select product unload times was obtained. In this, container size, work hours, box count, number of SKUs, number of workers involved with unload process, and price paid is provided. Table 3-1 displays a sample of the data for various imported products. Even though a lumper service was primarily used for floor loaded boxes, occasionally product arrives palletized and a lumper service unloads the contents using pallet jacks. When boxes arrive unitized on pallets in a container and cannot be unloaded with pallet jacks, a full time employee uses a forklift to unload the unit loads from the container. One example in the table displays that palletized products were unloaded by a lumper service from a container. For this case, pallet jacks were used to unload the container. It was noted that the facility doesn’t know exactly how many containers need to be unloaded per day until that morning (Operations Manager, personal communication, 2008).

Table 3-1 Sample List of Unload Times

Container Size (ft)	Work Hours	Box Count	#SKU's	#Workers	Wage Paid $
20'	2	537	12	2	$75.00
40'	1	42 Pallets	1	2	$118.00
40'	4	699	4	2	$118.00
40'	7	1228	15	2	$118.00
40'	6	1405	8	2	$118.00
40'	3	1484	11	3	$118.00
40' HC	5	400	1	2	$118.00
45'	4	875	2	1	$120.00

3.2.7 IDC & 3PL Field Study Four

Field study four was an IDC for low value household goods. No product is imported unitized in containers. Every product is floor loaded. According to management (2008) at the facility, it takes on average two to three employees seven work hours (14 to 21 man hours) to unload 1700 to 1800 boxes onto pallets. An average unload rate of 300 boxes per work hour is expected. The wage for employees unloading boxes ranges from $9.00 to $11.00 an hour. Seventy-seven percent of products are imported in 40' containers, 12 percent in 45'containers, 6 percent in 40' reefers, and 5 percent in 20' containers. Twenty foot containers are used when the product weighs out the container prior to cubing it out. Specific shipping costs were not revealed, but an average cost of $3,000 per 40' container was provided. Twenty foot containers cost 2/3 the price of a 40' container. For this facility, maximum allowable cargo weight for a 40' container is 42,500 lbs. Products are offloaded onto pallets, stored, and sent out via trailer floor loaded. Floor loading is utilized for imports and domestic shipments to maximize the transport mode capacity with product. (Management, personal communication, 2008)

3.2.8 IDC & 3PL Field Study Five

Field study five was a 3PL that imported an array of products including industrial grade chemicals, bagged products, and consumer commodities. According to the president of the company (2008), most industrial products are imported palletized; whereas, consumer products are often floor loaded to maximize container capacity. For floor loaded product, a lumper service is utilized. The lumper service charge to unload boxes of consumer product ranges from $100 to $150, depending on the product and size of the container. A charge to the customer for the unloading service ranges from $200 to $300. Some products are immediately loaded into an outbound trailer floor loaded, while others are palletized, stored, or immediately sent out palletized. It was noted that for product arriving palletized, the lumper service will be paid less if a forklift is used in the unloading operation. Full time employees were commonly utilized to unload palletized products from containers. A reoccurring issue was observed for super sacks arriving on pallets in containers. These sacks were intended to be a live unload, but took longer than the two hours allotted due to incompatibilities, resulting in additional charges. It was also observed that lumper services worked fast, but often carelessly. Observation revealed improper product placement on pallets which resulted in restack of products and potential product damage (President 3PL, personal communication, 2008).

3.2.9 IDC & 3PL Field Study Six

Field study six was an IDC handling ready to assemble (RTA) furniture. Unlike the other facilities visited, all imported products arrived unitized on pallets. The logistics manager (2009) revealed that, from shipment to shipment, various product/packaging sizes exist. Various pallet sizes are used to accommodate the varying sizes. Pallets are used because the product is heavy and if products were imported floor loaded, it would take a long time to unload. For some shipments, the product would weigh out the container by floor loading. Unitized products allow for a fast unload time. The time needed to empty a 40’ container of unit loads is 40 minutes.

Generally, two individuals are involved with the unloading operation. Unload labor is $17.55 an hour each. (Logistics Manager, 2009)

3.3 IDC & 3PL Field Study Container Loading Method Comparisons

Many of the IDC and 3PL field study facilities emphasized that floor loading was preferred to obtain more boxes per container. To verify more boxes could fit in a container floor loaded compared to on pallets and to determine the magnitude of the difference, box measurements and box product value were needed. Furthermore, box weights were collected to ensure container weights would not be exceeded by placing floor loaded boxes on pallets in containers. Field study location three and five permitted box measurements, weights, and product value to be recorded. Data was collected at location three and five on products arriving to the facility during the visit. A comparison for the two locations was made using TOPS (Total Optimization Packaging Software). To make the comparisons, pallets were assumed to weigh 30 pounds each.

3.3.1 Comparison One

A product observed at location three had box dimensions of 26 1/2” (length) x 14 5/8” (width) x 14 1/2” (height). The weight of each box was 79 pounds, and was valued at $120. The boxes were imported floor loaded with different box counts for the three containers observed. The variation in box count is displayed in Table 3-2. Boxes in container one and two were imported in a 40’ HC container. Boxes in container three were imported in a 40’ container.

Table 3-2 Varying Box Quantity of Same Product per Container

Container	Product Quantity	Unload Time
1	400	5 work hours
2	339	4 work hours
3	225	3 work hours

Inputting the dimensions and weights for the specific boxed product into TOPS verified that more boxes can be imported per container floor loaded compared to on pallets, with the exception of container three. The highest actual box count for floor loaded boxes was 400 boxes per container. Figure 3-1 displays the highest actual arrival of floor loaded boxes in a 40' HC container.

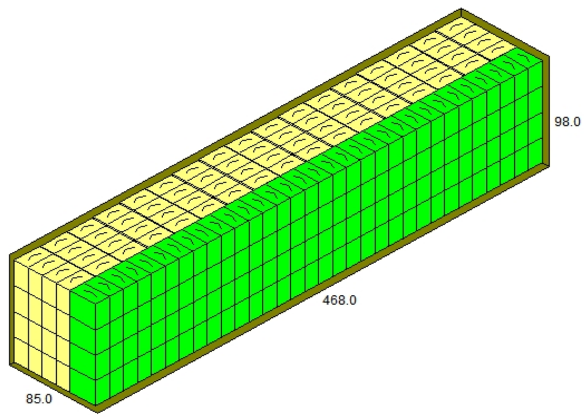

Figure 3-1 TOPS Model Boxes Floor Loaded in Container (400)

The observed floor loaded boxed products were unloaded onto pallets and shipped to retail four boxes per 48" x 40" pallet as shown in Figure 3-2. Due to the inefficient box fit on a 48" x 40" pallet, the 42" x 42" pallet size was selected for demonstration purposes to obtain the best fit of boxes to pallets and the highest box count per container. The box fit on a 42" x 42" pallet is shown in Figure 3-3.

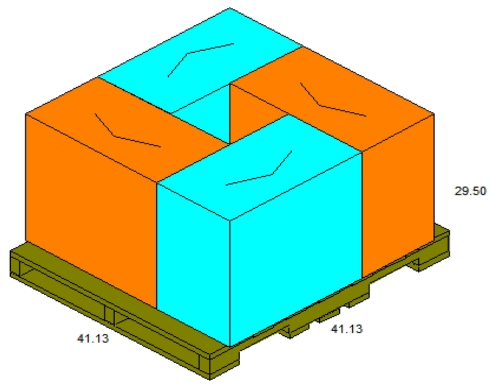

Figure 3-2 TOPS Model Four Boxes on a 48"x 40" Pallet

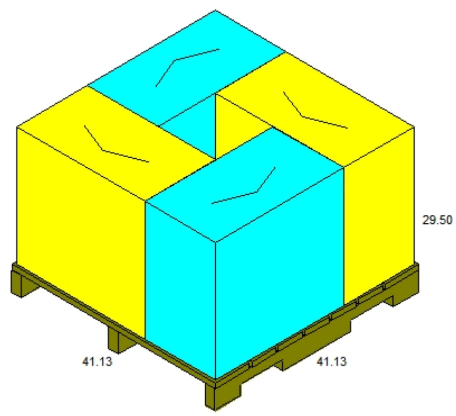

Figure 3-3 TOPS Model Four Boxes on a 42"x 42" Pallet

Assuming boxes arrive in containers palletized on 48" x 40" pallets (four boxes per pallet) only 252 boxes can fit in either a 40' or 40' HC container. Placing boxes on 42" x 42" pallets allows 264 boxes per container as shown in Figure 3-4.

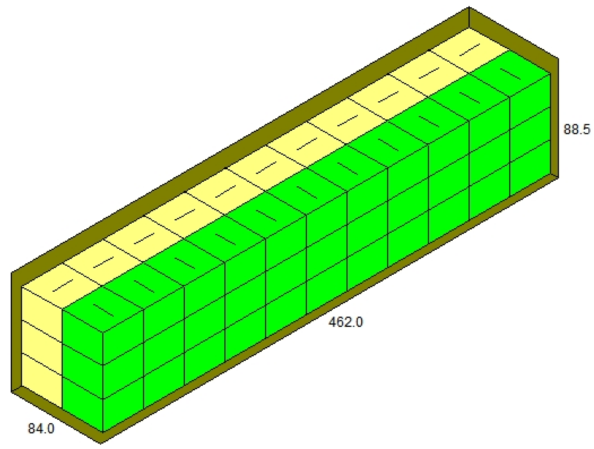

Figure 3-4 TOPS Model Boxes Palletized in Container (264)

By receiving 400 boxes in a 40’HC container, 136 more boxes are received floor loaded compared to on pallets. The additional 136 boxes per container results in an increased product arrival value of $16,320 per container. Table 3-3 displays results of floor loaded boxes and boxes unitized on pallets.

Table 3-3 Field Study Floor Loaded to Palletized Comparison 1

	Floor Loaded Actual	Palletized Optimal
Total product/packaging weight	31,600 lbs.	22,836 lbs.
Container Product Value	$48,000	$31,680
Boxes per vehicle	400	264
Cube Efficiency	81.7%	73.9%
Area Efficiency-package to pallet	Not Applicable	87.8%

3.3.2 Comparison Two

The above analysis was also completed for a product observed at location five. At this facility, 1848 boxes with dimension 26 7/8” x 6 5/8” x 11 1/8” were imported floor loaded. The product was valued at $100 per box, and weighed 12 pounds per box. Figure 3-5 shows 1848 boxes in a container.

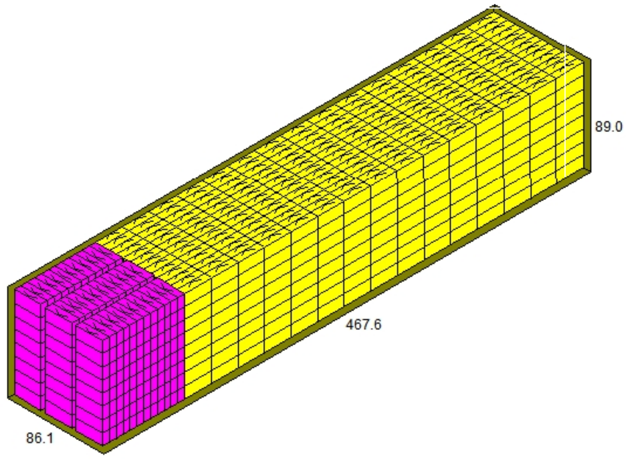

Figure 3-5 TOPS Model Boxes Floor Loaded in Container (1,848)

Placing the boxes on a 1200mm x1000mm pallet provided the best box to pallet fit and the highest box count per container. Box fit to pallet is shown in Figure 3-6. Figure 3-7 shows the 1200mm x 1000mm pallets in a container.

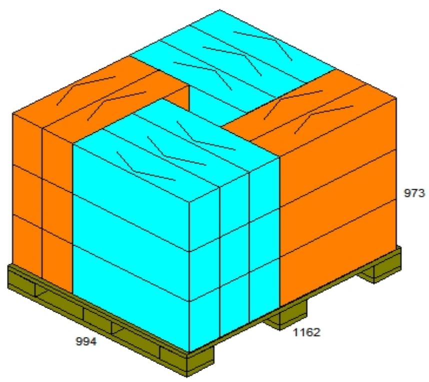

Figure 3-6 TOPS Model Boxes to Pallet Fit 1200mm x 1000mm

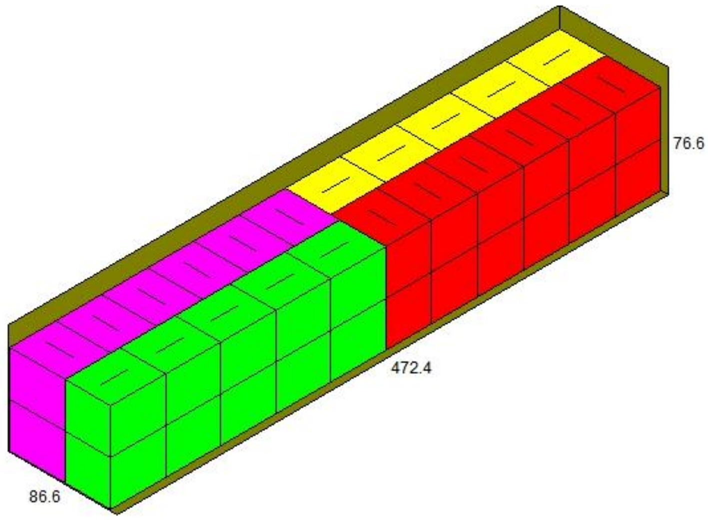

Figure 3-7 TOPS Model Boxes Palletized in Container (1,320)

A considerable difference of floor loaded box quantity and value compared to palletized box quantity is observed in Table 3-4.

Table 3-4 Field Study Floor Loaded to Palletized Comparison 2

	Floor Loaded Actual	Palletized
Total product/packaging weight	22,176 lbs.	17,100 lbs.
Container Product Value	$184,800	$132,000
Boxes per vehicle	1,848	1,320
Cube Efficiency	85.2%	75.8%
Area Efficiency-package to pallet	Not Applicable	92.1%

3.3.3 Summary of IDC & 3PL Field Studies

- With the exception of location six, the majority of boxed products imported into the facilities were floor loaded in containers upon arrival.
- Floor loading was utilized to obtain more boxes per container, maximize the container capacity with boxed products, and to obtain a higher container value.
- Time to unload and labor cost to unload containers was greater for floor loaded boxes compared to boxes unitized on pallets.
- Floor loaded boxes were often palletized at IDC or 3PL facilities.

- Labor was observed in three types and rates: lumper unloading floor loaded boxes, hourly manual unloading floor loaded boxes, and forklift operators unloading boxes unitized on pallets.
- For floor loaded boxes, regardless of product, or box count, utilizing a lumper service was cheaper to unload containers compared to hourly wage unloading floor loaded boxes.
- Lumper services worked fast, but carelessly. Improper placement of packages on pallets resulted in the potential for product/packaging damage.
- Incompatibilities between the boxed product and the pallet prohibited efficient unloading.
- Receiving dock doors were blocked for a longer duration when boxed product arrived floor loaded, resulting in drop containers rather than a live unload.
- When forklift handling was used, similar unload time and labor cost was observed, even when the product sectors were different (except super sacks). All locations had several forklifts and/or pallet jacks idle near receiving docks to move unit loads. Once employees offload boxes onto pallets, the pallets were either taken to storage or loaded into an outbound transport mode.
- Forklifts were the most cost effective method of unloading container contents.

3.3.4 Overall Benefit of Field Studies

From data and information collected through field studies, parameters for the model were obtained. By floor loading, more boxes could fit per container, but at higher labor costs, greater unload times, and dock doors being blocked for a longer duration. Unit loads were able to be unloaded at faster rates and at lowered prices from containers. If containers with boxes unitized on pallets could meet daily demand, then product value per day of the two loading methods would be equal. The difference would be derived from costs to meet daily demand. Containers that blocked doors for a long duration caused concern in terms of maximizing throughput and the ability to unload containers arriving simultaneously. For these reasons, receiving dock door capacity was included in the research. Based on obtainable information regarding costs and time from the field studies, a questionnaire was developed.

3.4 Questionnaire

3.4.1 Questionnaire Development

Collecting data during field studies focused on products arriving only at the time of the study. Random sampling of containers provided a general basis of the arrival of boxed products and a concept to develop a model, but did not provide enough specific information. The purpose of the questionnaire was to gather specific information about the highest volume products imported. A questionnaire was developed using www.survey.vt.edu (See Appendix 1 for the IRB (Institutional Review Board approval form, Appendix 2 for the recruiting script, and Appendix 3 for the questionnaire). Since data on highest volume imports was not collected in the field studies, the questionnaire was pretested utilizing field study participants. In addition to the field study participants, two other highly knowledgeable individuals affiliated with product imports were asked to participate in the pretest. Five out of the eight selected pretest participants responded.

3.4.2 Questionnaire Pretest Results

The following products were identified as highest volume imports. The product sector and geographic origin are provided.

- 1. Fans/Electrical Devices-China
- 2. Consumer Commodities-China

- 3. Furniture-Denmark
- 4. Produce-Latin America
- 5. Seasonal Products/decorations-China and Vietnam

From the pretest, only produce and furniture arrived unitized on pallets in containers. Other top imported products arrived to facilities floor loaded in containers. Products were found to arrive in 40’, 40’HC, 45’ containers, and 53’ trailers coming from Latin America. With the exception of Latin America taking one week to receive products, shipping times were nearly the same for all other facilities, ranging from three to six weeks. The number of containers arriving per day to be unloaded at the select facilities follows: 25 containers of seasonal items, 16 containers of fans/electrical devices, two containers of consumer commodities, one container of furniture, and 20 highway trailers of produce per day. Other than furniture, all shipping and drayage costs were paid by the buyers of the product. The furniture manufacturer initially pays the shipping and drayage charges for furniture because the manufacturer and IDC are the same company. Storage duration for the products identified in the questionnaire pretest ranged from one day to three months.

Unlike the products observed in the field studies, where commonly only one product box size occupied the container, the pretest unveiled that top imported products consist of mixed products of various sizes and weights per container. The average number of boxes per container, number of personnel involved with unloading containers, time to unload containers, charges, and the number of dock doors is provided in the following list:

1. Fans-Electrical Devices-1500 boxes per container
    - Two personnel, four work hours, paid $118 (lumper) to unload
    - No unload charge to customer (same company)

- 91 dock doors

2. Consumer Commodities-1000 boxes per container
    - Two to four personnel, two to four work hours, paid $125 (lumper) to unload
    - $225 charged to customer to unload
3. Furniture--355 boxes per container
    - Two personnel, 40 minutes, paid $17.55 an hour each
    - No unload charge to customer (same company)
    - Four to 10 dock doors
4. Produce-1500 boxes per container (or trailer)
    - One person, 45 minutes, paid $25 an hour,
    - cost to customer to unload not provided
    - 12 dock doors
5. Seasonal Products/decorations-200 to 2400 boxes per container
    - One to five personnel, wage not provided
    - cost to customer to unload not provided
    - 20 dock doors

3.4.3 Questionnaire Results

Based from the results and comments from the pretest, minor revisions were made to the questionnaire regarding box count, and mixed loads. The pretest contained pertinent data about top imports and was used in addition to data collected at other import facilities. One source to obtain questionnaire responses was through the Center for Unit Load Design's advisory board at Virginia Tech. One respondent was obtained through this method. Another source was through a directory of 3PLs and warehouses. From the directory of 55 facilities, 19 locations provided responses. Participant feedback provided: shipping duration, product loading method of highest volume imports, attributes of the product (package size, weight, value, number of boxes/products per container), demand, warehouse attributes, and associated import costs and times. The following sections summarize the responses of the questionnaires.

3.4.4 Shipping Duration

The amount of time for IDC and 3PL facilities to receive product, once ordered is shown in Figure 3-8. A range of one to nine weeks can be observed with the majority between three and six weeks. The range is based on 23 respondents; two did not provide a response for the shipping duration.

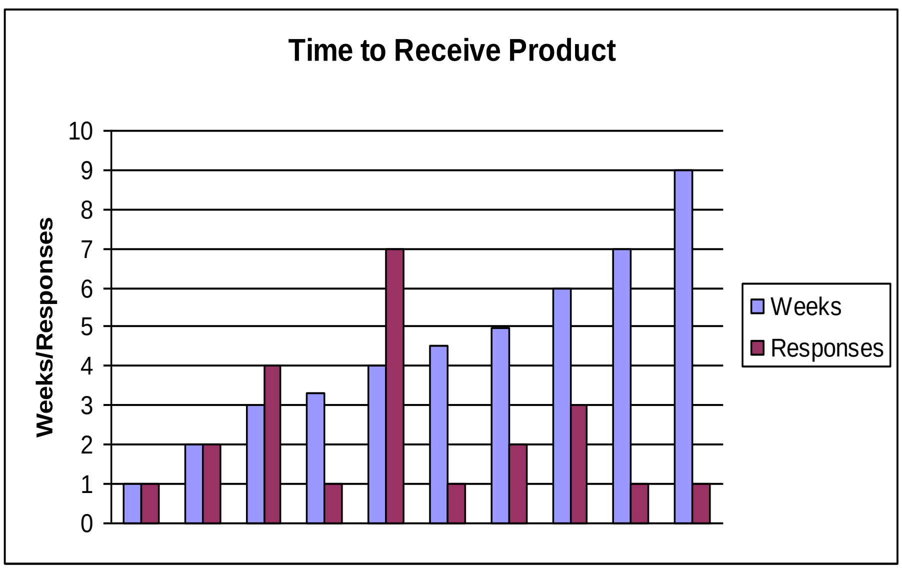

Figure 3-8 Shipping Duration

3.4.5 Container Cargo Loading Method

Data obtained from the questionnaire revealed that the majority of product imports were floor loaded or palletized upon arrival to IDC and 3PL facilities as shown in Figure 3-9. One questionnaire respondent indicated that the product commonly arrived palletized but occasionally on slip sheets (represented as palletized/slip sheets). For this case, data provided on pallets was used in the study. One respondent indicated that the product arrived in bulk. Product that arrives unpackaged in bulk cannot be palletized and does not share common warehousing attributes as boxes arriving floor loaded or unitized on pallets. The product imported in bulk was removed from the study.

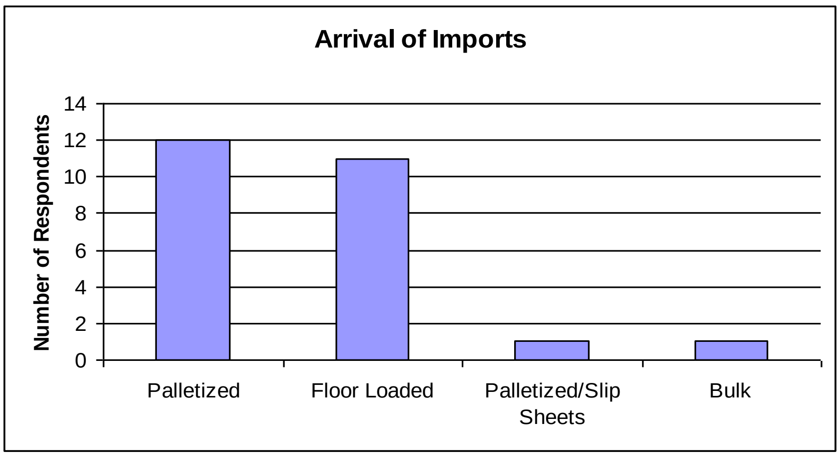

Figure 3-9 Various Loading Methods Identified

One respondent indicated that the highest volume import was machinery. The machinery was floor loaded and unloaded with a forklift. Labor and time to unload floor loaded machinery with a forklift is not relevant to the study. However, warehouse attributes are relevant. Boxed products were the focus of the study, but many imported boxed products are not palletized. For comparison purposes, data regarding imported palletized cargo, regardless if boxed or not, was considered for the research. Fruit imported from Latin America was found to arrive in 53' trailers. Data obtained about fruit was relevant, as unloading methods for trailers are similar to containers.

3.4.6 Specific Data on Container Cargo

Imports from various countries and regions were identified through the questionnaires. Table 3-5 displays: product sector, country/region of origin, floor loaded or palletized, container size, pallet size if applicable, and whether the container consists of single stock keeping units (SKU) (all same dimensions) or mixed SKU (different dimensions). For many imports arriving palletized, respondents indicated pallet size varies from shipment to shipment and is not consistent. Other respondents indicated imports arrive on 48” x 40,” 1200mm x 1000mm, and 40” x 40” pallets. The majority of respondents indicated that imports arrive in 40’ standard containers. Wine/beer and cosmetics are imported in both 20’ and 40’ containers. Produce is imported in 53’ trailers.

Table 3-5 Questionnaire Results Regarding Container Cargo

Top Imported Product	Country/Region Origin	Floor Loaded Palletized	Container Size	Mix/Single SKU Container
Fans-Electrical Devices	China	Floor Loaded	40'	Mixed
Consumer Commodities	China	Floor Loaded	40' HC	Mixed
Seasonal Items	China, Vietnam	Floor Loaded	45' HC	Mixed
Seafood-Fish	Argentina, China	Floor Loaded	40'	Single
Cosmetics	China	Floor Loaded	20' & 40'	Mixed
Food	China	Floor Loaded	40' HC	Single
Shrimp	Vietnam	Floor Loaded	40' HC	Single
Household Goods	China	Floor Loaded	40'	Mixed
Peanuts	Argentina, China	Floor Loaded	40'	Single
Molded Plastic Goods	Israel	Floor Loaded	40'	Single
*Furniture	Denmark	Palletized	40' HC	Mixed
(1) Wine and Beer	All selections & Australia	Palletized	20' & 40'	Mixed
*Sector Not Provided	Sweden	Palletized	40'	Mixed
*Forgings/Castings	India	Palletized	20'	Single
*Stone Products	China	Palletized	20'	Mixed
*Spices	S.E Asia	Palletized	40'	Single
**Produce	Latin America	Palletized	53' Trailer	Mixed
**Energy Drink	Austria/Switzerland	Palletized	40'	Single
**Beverages	United Kingdom	Palletized	40'	Single
**Non Hazardous Chemicals	Germany and Brazil	Palletized	40'	Mixed
***Electric Motors	China	Palletized	40'	Single
***Food Products	Spain	Palletized	20' HC	Single
****Fiberglass	China	Palletized	20' HC	Single

(1) All selections can be found in Appendix 3, question #4, respondent also indicated product arrives on pallets and occasionally on slip sheets

*Imports arrive on various pallet sizes
**Imports arrive on a 48” x40” pallet
***Imports arrive on a 1200mm x 1000mm pallet
****Imports arrive on 40”x 40” pallet

3.4.7 Shipping and Drayage Costs

It was found from the questionaires that shipping costs ranged from $2,400 to $4,000. Through converstation with the senior vice president for a major ship line (2009), it was found that $1,500 for a 20' container and $3,000 for a 40' container were average rates regardless of the weight of the contents. Most shippers operate under a lump sum charge. Often, port charges are included in the shipping cost (Senior Vice President, personal communication, 2009). Drayage from the port to the IDC or 3PL facility ranged from $150-$375. Several responses indicated a fuel surcharge also exists in addition to the base cost.

3.4.8 Labor Costs

Data collected regarding labor required to unload containers can be divided into three categories. The categories follow:

- Lumper, paid by the container, utilized primarily for floor loaded imports
- Full time and part time paid hourly, utilized for floor loaded imports
- Forklift operators, utilized to unload palletized imports with a forklift

Tables 3-6, 3-7, and 3-8 display the results, respectively. The tables display the total amount of work hours needed to unload a container, number of workers involved with the unloading process, actual total cost for labor to unload a container (no profit), and the customer cost (cost + profit). Unload times, costs, and customer charge are also displayed as minimum, average, and maximum. Total unloading cost combines time and labor, and only considers labor in the unloading process. Pallets, securing devices such as banding and stretch wrap, and/or warehouse services such as storage and/or value added services would result in additional charges. Customer charge is also portrayed just for labor in the unloading process. Like total unloading costs, additional charges are likely.

Table 3-6 Lumper Costs to Unload Floor Loaded Boxes

Status	Time (hours)	Workers	Total Unloading Cost ($)	Customer Charge ($)
Lumper (Floor Loaded)	4.00	2	118.00	0.00
Lumper (Floor Loaded)	3.00	3	125.00	225.00
Lumper (Floor Loaded)	2.00	3	150.00	200.00
Lumper (Floor Loaded)	3.00	3	NA	300.00
Lumper (Floor Loaded)	4.00	2	120.00	390.00
Lumper (Floor Loaded) Minimum	**2.00**	**2**	**118.00**	**200.00**
Lumper (Floor Loaded) Average	**3.20**		**129.60**	**278.75**
Lumper (Floor Loaded) Maximum	**4.00**	**3**	**150.00**	**390.00**

Table 3-7 Hourly Wage Costs to Unload Floor Loaded Boxes

Status	Time (hours)	Workers	Total Unloading Cost ($)	Customer Charge ($)
Hourly Wage (Floor Loaded)	4.00	3	132.00	465.00
Hourly Wage (Floor Loaded)	2.00	3	63.00	740.00
Hourly Wage (Floor Loaded)	2.00	3	66.00	312.00
Hourly Wage (Floor Loaded)	3.00	2	54.00	325.00
Hourly Wage (Floor Loaded) Minimum	**2.00**	**2**	**54.00**	**312.00**
Hourly Wage (Floor Loaded) Average	**2.75**		**78.75**	**460.50**
Hourly Wage (Floor Loaded) Maximum	**4.00**	**3**	**132.00**	**740.00**

Table 3-8 Forklift Operator Costs to Unload Boxes in Unitized Form

Status	Time (hours)	Workers	Total Unloading Cost $	Customer Charge $
Forklift Operator (Palletized)	0.66	2	23.40	0.00
Forklift Operator (Palletized)	0.58	2	16.33	NA
Forklift Operator (Palletized)	0.75	1	18.75	NA
Forklift Operator (Palletized)	0.75	2	22.50	NA
Forklift Operator (Palletized)	0.75	1	7.50	NA
Forklift Operator (Palletized)	0.33	1	5.00	NA
Forklift Operator (Palletized)	0.33	1	4.54	150.00
Forklift Operator (Palletized)	1.00	1	20.00	25.00
Forklift Operator (Palletized)	2.00	1	30.00	150.00
Forklift Operator (Palletized)	0.50	1	5.00	287.00
Forklift Operator (Palletized)	1.00	1	12.65	100.00
Forklift Operator (Palletized)	0.50	2	13.00	125.00
Forklift Operator (Palletized)	0.66	1	6.66	300.00
Forklift Operator (Palletized) Minimum	**0.33**	**1**	**4.54**	**25.00**
Forklift Operator (Palletized) Average	**0.84**		**14.26**	**162.43**
Forklift Operator (Palletized) Maximum	**2.00**	**2**	**30.00**	**300.00**

3.4.9 Containers Demand per Day

Table 3-9 displays the minimum, average, and maximum number of containers found to arrive daily to IDC or 3PL facilities.

Table 3-9 Containers Received per Day

Minimum	1 per Day
Average	6 per Day
Maximum	35 per Day

3.4.10 Receiving Dock Doors

The volume of product a facility is able to process in a day is regulated by the number of dock doors a facility has, as well as the method of labor used to unload contents from containers. The minimum, average, and maximum number of dock doors obtained from the questionnaires were found to be four, 29, and 160, respectively.

3.4.11 Storage Duration

Once product is unloaded, storage times vary. In one instance, product was found to be loaded immediately into an outbound trailer. Other storage results ranged from 24 hours to two years.

3.4.12 Solutions to a Demand Increase

The majority of responses indicated that if demand were to increase, a way to accommodate it would be to increase labor. Figure 3-10 displays the results.

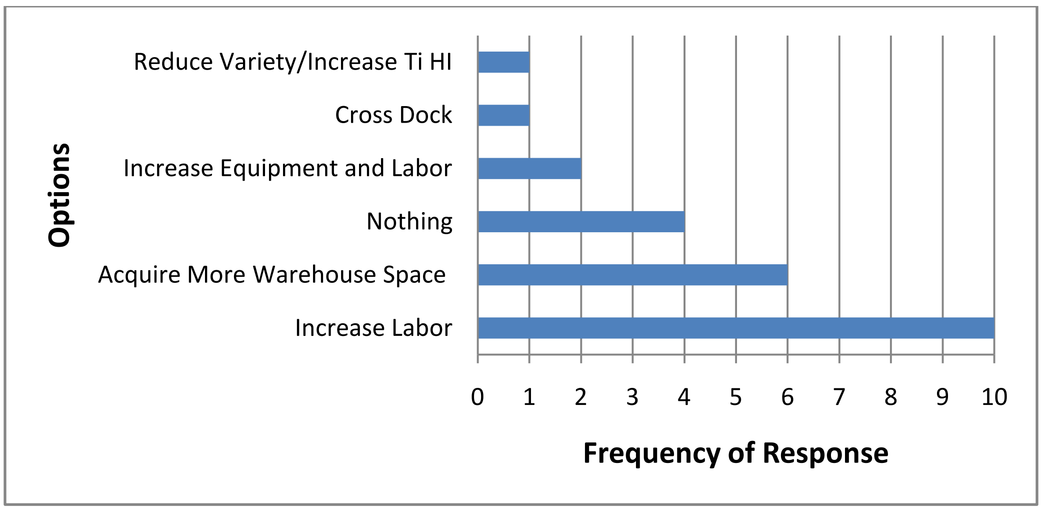

Figure 3-10 Demand Increase Solutions

3.4.13 Labor Cost Increase

The majority of responses indicated that if labor charges were to increase, the cost would be passed onto the customer. Figure 3-11 displays the results for an increase in labor charges.

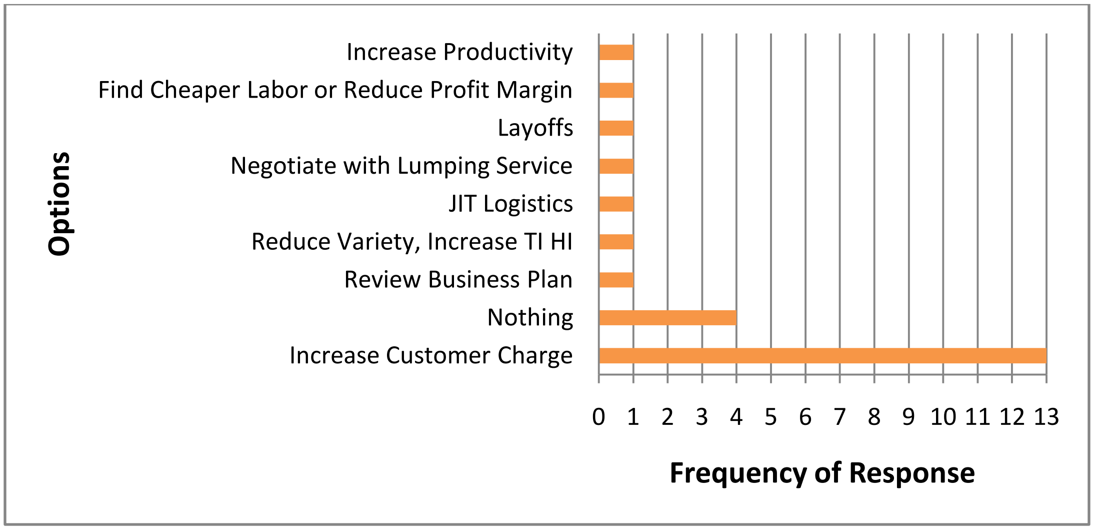

Figure 3-11 Labor Cost Increase Solutions

3.4.14 Capacity Utilization

Current warehouse and distribution center capacity utilization was determined and is shown in Figure 3-12. Warehouses at or near capacity do not have many options to take on other products, or to process an increase in demand of existing products.

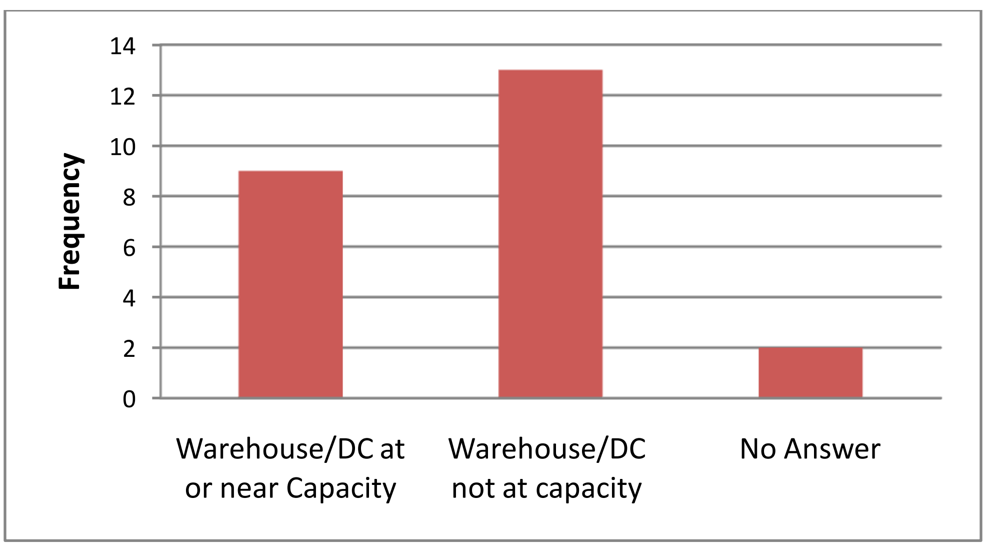

Figure 3-12 Warehouse Capacity Utilization

CHAPTER 4. MODEL DEVELOPMENT

4.1 Overview of Model

Through this research, the types of products that are floor loaded or palletized in containers was determined. More importantly, the influencing variables that need to be considered to make an efficient (cost and time) decision were identified. The influencing variables are:

- Box dimensions and volume
- Boxed product weight
- Pallet phytosanitation cost
- Pallet purchase Cost
- Number of boxes per container
- Number of boxes per pallet
- Number of pallets per container
- Shipping and handling costs
- Box/container demand
- Single SKU or mixed SKU container
- Unload times
- Available receiving dock doors

By incorporating the variables into a model, a method to make an efficient decision to either floor load boxes or unitize boxes on pallets in containers was obtained. Through this research, it was found that boxes were often floor loaded to obtain more boxes per container, which resulted in a higher container value. For an efficient decision to be made, it is important to consider the value of containers meeting daily demand (not on a container basis), associated costs, time, and processing capability of the receiver for the two container cargo loading methods. Through the development of the model, several terms are referenced. Definitions and/or the origin of these terms used in the model are provided in Appendix 4 (Definitions of the Model).

A cost comparison is made in the model by determining the value of containers per day less shipping and handling costs for the two loading methods (net value). Comparing the net values (subtracting net value for boxes unitized on pallets from the net value of floor loaded boxes) results a cost benefit (net value delta) for one of the two loading methods. The model considers full and partially filled containers. In addition to verifying the most cost efficient method of exporting/importing boxed products, the model incorporates the ability of the receiver to unload products from containers, based upon time and receiving dock doors available. It was found that container traffic is variable due to demand fluctuations and the uncertainty of container arrival. Dock door availability needs to be considered for both the distribution center and the buyer, to ensure product can be unloaded and further distributed in a timely manner. To determine which loading method is most efficient in terms of the ability to process the amount of containers, the model considers, number of doors, time to unload containers, time to move a container from a dock door (if applicable), number of containers to be processed, and the available hours of the receiving dock door. Consideration is given to the ability to meet demand and to maximize throughput.

The model provides a method to make a decision for single SKU containers, followed by a separate method to make a decision for mixed SKU containers.

4.2 Single SKU Model Sequence

For Single SKU containers, the first step to applying the model is to input the box dimensions and box weight into TOPS or a similar software program. To determine the proper container type and size, the number of boxes desired per container, boxed product weight, size, and other attributes need to be considered. For boxes that are unitized on pallets in a container, TOPS requires the user to choose a pallet style, weight, and size. It is assumed one will be selected that has the proper strength to support the boxed product, a good fit for the boxed product (ideally no over-hang and minimal under-hang), and is compatible for the receiver. The software allows a comparison to be made of the maximum number of boxes floor loaded to the maximum number of boxes unitized on pallets (considering pallet configuration) that fit in a container. The maximum number of boxes obtained from TOPS for the two loading methods are assumed to be full containers (unusable space due to box size or weight in containers is likely). Container weight, including boxed products and pallets (if applicable) is provided from TOPS. By determining the number of boxes that fit in a container floor loaded and the number of boxes that fit in a container unitized on pallets, calculations can be developed for the following: container value, containers to meet daily demand, value meeting daily demand, costs per container, cost to meet demand, net value, net value delta, and dock capacity for the two loading methods. For each calculation, a table is provided defining the associated variables for the two loading methods, followed by an equation(s) for each loading method.

4.2.1 Single SKU Container Value

For this model, value has no bearing on the overall decision to floor load or unitize boxes. Using equal values of the boxed product for the two loading methods will provide the same result, regardless of what the value is. Value provides a basis for costs to be subtracted from and was used to show that the daily container values for the two loading methods could be equal. Container value for floor loaded containers is obtained by multiplying the maximum number of boxes floor loaded that fit in a container, or that maximize the container weight capacity by the individual box value. For boxes unitized on pallets, the container value is obtained by multiplying the maximum number of boxes that fit in a container on pallets, or that maximize the container weight capacity by the individual box value.

Table 4-1 Single SKU Container Value Floor Loaded Defined

Abbreviation	Definition
$Nfbc$	Number of Floor Loaded boxes per Full Container
Vb	Value of Individual Box
Vfc	Value of Floor Loaded Container

Single SKU Container Value Floor Loaded

$$Nfbc \times Vb = Vfc \text{ (\$)} \tag{4-1}$$

Table 4-2 Single SKU Container Value Palletized Defined

Abbreviation	Definition
$Nbpc$	Number of Boxes Palletized per Full Container
Vb	Value of Individual Box
Vpc	Value of Palletized Container

Single SKU Container Value Palletized

$$Nbpc \times Vb = Vpc \text{ (\$)} \tag{4-2}$$

4.2.2 Single SKU Containers Meeting Daily Demand

To determine the number of containers required per day, box demand per day must also be available. Containers needed to meet daily demand will not be the same if the number of boxes per container floor loaded does not equal the number of boxes unitized on pallets per container. So a comparison can be made, box demand per day floor loaded needs to equal box demand per day palletized. The total number of floor containers needed per day is obtained by dividing the number of boxes per day by the number of boxes per container for each loading method (*Nfbc* and *Nbpc*).

Table 4-3 Single SKU Containers Meeting Demand Floor Loaded Defined

Abbreviation	Definition
Nbd	Number of Boxes needed per Day
$Nfbc$	Number of Floor Loaded Boxes per Full Container
$Tfcd$	Total Number of Floor Loaded Containers needed per Day

Single SKU Containers Meeting Demand Floor Loaded

$$Nbd \div Nfbc = Tfcd\ (Containers) \tag{4-3}$$

Table 4-4 Single SKU Containers Meeting Demand Palletized Defined

Abbreviation	Definition
Nbd	Number of Boxes needed per Day
$Nbpc$	Number of Boxes Palletized per Full Container
$Tpcd$	Total Number of Palletized Containers needed per Day

Single SKU Containers Meeting Demand Palletized

$$Nbd \div Nbpc = Tpcd\ (Containers) \tag{4-4}$$

4.2.3 Single SKU Product Value Meeting Daily Demand

Inputting the container value for floor loaded/palletized boxes and the number of floor loaded/palletized containers needed per day provides the product value per day. Since the number of boxes and individual box values are the same, the product value per day is equal for both loading methods. Product value is a resultant of multiplying the number of boxes needed to meet daily demand by the individual box value.

Table 4-5 Single SKU Product Value Floor Loaded Meeting Demand Defined

Abbreviation	Definition
Nbd	Number of Boxes needed per Day
Vb	Value of Individual Box
$PVdf$	Product Value per Day Floor Loaded

Single SKU Product Value Floor Loaded Meeting Demand

$$Nbd \times Vb = PVdf\ (\$) \tag{4-5}$$

Table 4-6 Single SKU Product Value Palletized Meeting Demand Defined

Abbreviation	Definition
Nbd	Number of Boxes needed per Day
Vb	Value of Individual Box
$PVdp$	Product Value per Day Palletized

Single SKU Product Value Palletized Meeting Demand

$$Nbd \times Vb = PVdp\ (\$) \tag{4-6}$$

4.2.4 Single SKU Costs per Container

The next step is to determine the total shipping and handling costs of the boxes per container. The calculation for floor loaded and palletized boxes assumes containers are full. Labor cost to load ($LCfc, LCpc$) and labor cost to unload ($LCufc,$ and $LCupc$) can be either actual costs (no profit) or costs to customer (actual + profit) for the two loading methods. Once a container arrives to an IDC or 3PL facility to be unloaded, pallets are likely needed to offload boxes. For floor loaded containers, the first step in determining the cost per full container is to divide the maximum number of boxes floor loaded by the number of boxes per pallet. Multiplying the result by the individual pallet cost results the total pallet cost per floor loaded container. The total pallet cost per floor loaded container is added to the labor cost to unload a container, which results the cost to unload as shown in Equation 4-7-1. In Equation 4-7-2 the total cost per full floor loaded container is obtained by summing the labor cost to load a container, export drayage cost, shipping cost, import drayage cost, and cost to unload.

For containers arriving to IDCs and 3PLs with contents palletized, the pallet cost is incorporated on the loading end. If wood is the choice pallet material, an additional phytosanitation cost is considered. The cost to load unit loads in a container is obtained by adding the phytosanitation cost to the individual pallet cost. The result is multiplied by the number of pallets needed per container, and added to the labor cost to load a container as shown in Equation 4-8-1. The total cost per full container is obtained from Equation 4-8-2 by summing the cost to load, export drayage cost, shipping cost, import drayage cost and unloading cost. In certain cases additional pallets may be needed if the pallet configuration is altered after arrival to IDC or 3PL facility. In this case, manual labor may be needed to de-palletize some boxes and re-palletize on additional pallets. For this case, manual labor costs and additional pallet cost should be included in the cost to unload.

Table 4-7 Single SKU Costs Floor Loaded Container Defined

Abbreviation	Definition
$LCufc$	Labor Cost to Unload a Floor Loaded Container
$Nfbc$	Number of Floor Loaded boxes per Full Container
$NbpI$	Number of Boxes per Pallet Importer
pCI	Pallet Cost Importer
$Cufc$	Cost (labor and pallets) to Unload a Floor Loaded Container
$LCfbc$	Labor Cost to Floor Load boxes in a Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$TCFfc$	Total (Shipping and Handling) Costs per Full Floor Loaded Container

Single SKU Cost to Unload a Full Floor Loaded Container

$$LCufc + ((Nfbc \div NbpI) \times PCI) = Cufc\ (\$) \qquad (4\text{-}7\text{-}1)$$

*If $Nfbc \div NbpI$ is not a whole number, roundup to the nearest whole number.

Single SKU Total Cost per Full Floor Loaded Container

$$LCfbc + DCEc + SCc + DCIc + Cufc = TCFfc\ (\$) \qquad (4\text{-}7\text{-}2)$$

Table 4-8 Single SKU Costs Palletized Container Defined

Abbreviation	Definition
$LCpc$	Labor Cost to Load Pallets per Container
pCE	Pallet Cost Exporter
pTC	Pallet Treatment Cost
$Nbpc$	Number of Boxes Palletized per Full Container
$NbpE$	Number of Boxes per Pallet Exporter
Cpc	Cost (labor and pallets) to Load Palletized Boxes in a Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$LCupc$	Labor Cost to Unload Palletized Boxes per Container
pCI	Pallet Cost Importer
$TpIc$	Total Number of Pallets needed Importer
$TCFpc$	Total (Shipping and Handling) Costs per Full Palletized Container

Single SKU Cost to Load Unit Loads in a Container

$$LCpc\ + ((pCE\ + pTC) \times (Nbpc \div NbpE))\ = Cpc\ (\$) \tag{4-8-1}$$

* If $Nbpc \div NbpE$ is not a whole number, roundup to the nearest whole number.

Total Cost per Full Container with Contents Palletized

$$Cpc + \ DCEc + \ SCc + DCIc + LCupc + (pCI \times TpIc) = \ TCFpc\ (\$) \tag{4-8-2}$$

*If additional pallets are needed for importer, then$(pCI \times TpIc)$; if no additional pallets are needed, then (0, 0). If manual labor is needed, then add to $LCupc$.

4.2.5 Single SKU Partial Cost for Partially Filled Containers

In some cases, partial containers may exist to meet demand. Comparing floor loaded boxes to boxes unitized on pallets, it is likely a partial excess container will be needed. For this case, partial containers are charged only for space utilized in the container for shipping and drayage. A partial labor cost is applied, unless a lumper service is utilized. When a partial shipping and drayage charge is applied, it is assumed that the remaining excess container will be filled with other products and the remaining costs will be absorbed by other products. For floor loaded containers and containers with contents palletized, the labor cost to load excess boxes, dray, ship, and unload is proportional to the cost of a full container. Each is divided by the number of boxes per full container, times the number of excess boxes per container as shown in Equations 4-9-1 through 4-9-5 for floor loaded boxes and in Equations 4-10-1 through 4-10-5 for boxes unitized on pallets. For calculations considering pallets (Equation 4-9-5 for floor loaded boxes and Equations 4-10-1 and 4-10-5 for boxes unitized on pallets), the calculations are similar to full containers, but the number of excess boxes is considered instead of the number of boxes per full container. The total cost per excess container charged partial for the two loading methods is obtained by summing the loading cost, export drayage cost, shipping cost, import drayage cost, and unloading cost, shown in Equation 4-9-6 for boxes floor loaded and Equation 4-10-6 for boxes unitized on pallets.

Table 4-9 Single SKU Partial Container Costs Floor Loaded Defined

Abbreviation	Definition
$LCfbc$	Labor Cost to Floor Load Boxes per Container
$Nfbc$	Number of Floor Loaded Boxes per Full Container
$efbc$	Excess Floor Loaded Boxes per Container
$LCfebc$	Labor Cost to Floor Load Excess Boxes per Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$DCEebc$	Drayage Cost Exporter for Excess Boxes Floor Loaded per Container
$SCebc$	Shipping Cost for Excess Boxes Floor Loaded per Container
$DCIebc$	Drayage Cost Importer for Excess Boxes Floor Loaded per Container
$LCufc$	Labor Cost to Unload Floor Loaded Boxes from a Container
$NbpI$	Number of Boxes per Pallet Importer
pCI	Pallet Cost Importer
$Cuefc$	Cost (labor and pallets) to Unload Excess Floor Loaded Boxes per Container
$TCefc$	Total (Shipping and Handling) Cost for an Excess Floor Loaded Container (used only if a partial container exists to meet demand and is charged partial shipping/ transport costs, and partial labor)

Single SKU Labor Cost to Floor Load Excess Boxes in a Container

$$(LCfbc \div Nfbc) \times efbc = LCfebc\ (\$) \qquad (4\text{-}9\text{-}1)$$

Single SKU Drayage Cost Exporter for Excess Boxes per Container

$$(DCEc \div Nfbc) \times efbc = DCEebc\ (\$) \qquad (4\text{-}9\text{-}2)$$

Single SKU Shipping Cost for Excess Boxes per Container

$$(SCc \div Nfbc) \times efbc = SCebc\ (\$) \qquad (4\text{-}9\text{-}3)$$

Single SKU Drayage Cost Importer for Excess Boxes Floor Loaded per Container

$$(DCIc \div Nfbc) \times efbc = DCIebc\ (\$) \qquad (4\text{-}9\text{-}4)$$

Single SKU Cost to Unload Excess Floor Loaded Boxes per Container

$$((LCufc \div Nfbc) \times efbc) + ((efbc \div NbpI) \times pCI) = Cuefc\ (\$) \qquad (4\text{-}9\text{-}5)$$

* If $efbc \div NbpI$ is not a whole number, roundup to the nearest whole number

Single SKU Total Cost for an Excess Floor Loaded Container Partial Charged

$$LCfebc + DCEebc + SCebc + DCIebc + Cufec = TCefc\ (\$) \qquad (4\text{-}9\text{-}6)$$

Table 4-10 Single SKU Partial Container Costs Palletized Defined

Abbreviation	Definition
$LCpc$	Labor Cost to Load Palletized Boxes per Container
$Nbpc$	Number of Boxes Palletized per Full Container
$ebpc$	Excess Boxes Palletized per Container
pCE	Pallet Cost Exporter
pTC	Pallet Treatment Cost
$NbpE$	Number of Boxes per Pallet Exporter
$Cpec$	Cost (Labor and Pallets) to Load Excess Palletized Boxes in a Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$DCEepc$	Drayage Cost Exporter for Excess Palletized Boxes per Container
$SCepc$	Shipping Cost for Excess Palletized Boxes per Container
$DCIepc$	Drayage Cost Importer for Excess Palletized Boxes per Container
$LCupc$	Labor Cost to Unload Palletized Boxes from a Container
pCI	Pallet Cost Importer
$TepIc$	Total Number Excess Pallets needed per Import Container
$Cuepc$	Cost (labor and pallets) to Unload Excess Boxes Palletized from Container
$TCepc$	Total (Shipping and Handling) Cost for an Excess Palletized Container (used only if partial container exists to meet demand and is charged partial shipping and transport costs, and partial labor)

Single SKU Cost to Load Excess Boxes Palletized per Container

$$\left((LCpc \div Nbpc) \times ebpc\right) + ((pCE + pTC) \times (ebpc \div NbpE)) = Cpec\ (\$) \qquad (4\text{-}10\text{-}1)$$

* If $ebpc \div NbpE$ is not a whole number, roundup to the nearest whole number

Single SKU Drayage Cost Exporter for Excess Palletized Boxes per Container

$$(DCEc \div Nbpc) \times ebpc = DCEepc\ (\$) \qquad (4\text{-}10\text{-}2)$$

Shipping Cost for Excess Palletized Boxes per Container

$$(SCc \div Nbpc) \times ebpc = SCepc\ (\$) \qquad (4\text{-}10\text{-}3)$$

Drayage Cost Importer for Excess Palletized Boxes per Container

$$(DCIc \div Nbpc) \times ebpc = DCIepc\ (\$) \qquad (4\text{-}10\text{-}4)$$

Cost to Unload Excess Boxes Palletized from a Container

$$(LCupc \div Nbpc) \times ebpc + (pCI \times TePIc) = Cuepc\ (\$) \qquad (4\text{-}10\text{-}5)$$

*If additional pallets are needed for importer, then $(pCI \times TpIc)$; if no additional pallets are needed, then (0, 0).

Total Cost for an Excess Palletized Container Partially Charged

$$Cpec + DCEepc + SCepc + DCIepc + Cuepc = TCepc\ (\$) \qquad (4\text{-}10\text{-}6)$$

4.2.6 Single SKU Cost Meeting Daily Demand Full Charged Containers

For shipments that cannot meet demand in full containers, excess container space exists. Unlike the previous calculations, these calculations assume that space cannot be utilized by other products. This scenario results in full shipping and drayage costs and partial handling costs. When a lumper service (paid by the container, not by the hour) is used a full container labor cost to load/unload should be considered. Only the last container of the shipment to meet demand should be considered for this option, and only if excess space and costs cannot be absorbed by additional products. Prior containers are assumed full, and will be charged full transport, shipping and full labor cost. Like partial charged containers, the cost to load and unload is proportional to the cost of a full container as shown in Equations 4-11-1 and 4-11-2 for boxes floor loaded and in Equations 4-12-1 and 4-12-2 for boxes unitized on pallets. However, export drayage, shipping and import drayage are full rates. Summing the costs for both loading methods results a total cost for an excess container (* represents excess container charged in full), shown in Equation 4-11-3 for boxes floor loaded and 4-12-3 for boxes unitized on pallets.

Table 4-11 Single SKU Full Charged Partial Containers Floor Loaded Defined

Abbreviation	Definition
$LCfbc$	Labor Cost to Floor Load Boxes per Container
$Nfbc$	Number of Floor Loaded Boxes per Full Container
$efbc$	Excess Floor Loaded Boxes per Container
$LCfebc$	Labor Cost to Floor Load Excess Boxes Floor Loaded in Container
$LCufc$	Labor Cost to Unload Floor Loaded Boxes from a Container
$NbpI$	Number of Boxes per Pallet Importer
pCI	Pallet Cost Importer
$Cuefc$	Cost (labor and pallets) to Unload Excess Floor Loaded Boxes per Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$TCefc^*$	Total (Shipping and Handling) Costs for an Excess Floor Loaded Container (used only if a partial container exists to meet demand and is charged full shipping/ transport costs, and partial labor)

Single SKU Labor Cost to Floor Load Excess Boxes Floor Loaded in Container

$$(LCfbc \div Nfbc) \times efbc = LCfebc\ (\$) \tag{4-11-1}$$

Single SKU Cost to Unload Excess Floor Loaded Boxes per Container

$$((LCufc \div Nfbc) \times efbc) + ((efbc \div NbpI) \times pCI) = Cuefc\ (\$) \tag{4-11-2}$$

* If $efbc \div NbpI$ is not a whole number, roundup to the nearest whole number

Single SKU Total Cost for an Excess Floor Loaded Container Full Charged

$$LCfebc + DCEc + SCc + DCIc + Cufec = TCefc^*(\$) \tag{4-11-3}$$

Table 4-12 Single SKU Full Charged Partial Containers Palletized Defined

Abbreviation	Definition
$LCpc$	Labor Cost to Load Palletized Boxes per Container
$Nbpc$	Number of Boxes Palletized per Full Container
$ebpc$	Excess Boxes Palletized per Container
pCE	Pallet Cost Exporter
pTC	Pallet Treatment Cost
$NbpE$	Number of Boxes per Pallet Exporter
$Cpec$	Cost (Labor and Pallets) to Load Excess Palletized Boxes in a Container
$LCupc$	Labor Cost to Unload Palletized Boxes from a Container
pCI	Pallet Cost Importer
$TepIc$	Total Number Excess Pallets needed per Import Container
$Cuepc$	Cost (labor and pallets) to Unload Excess Boxes Palletized from Container
$DCEc$	Drayage Cost Exporter per Container
SCc	Shipping Cost per Container
$DCIc$	Drayage Cost Importer per Container
$TCepc^*$	Total (Shipping and Handling) Costs for an Excess Palletized Container (used only if partial container exists to meet demand and is charged full shipping and transport costs, and partial labor

Single SKU Cost to Load Excess Palletized Boxes in a Container

$$\big((LCpc \div Nbpc) \times ebpc\big) + ((pCE + pTC) \times (ebpc \div NbpE)) = Cpec\ (\$) \qquad (4\text{-}12\text{-}1)$$

* If $ebpc \div NbpE$ is not a whole number, roundup to the nearest whole number.

Single SKU Cost to Unload Excess Boxes Palletized from Container

$$((LCupc \div Nbpc) \times ebpc) + (pCI \times TePIc) = Cuepc\ (\$) \qquad (4\text{-}12\text{-}2)$$

*If additional pallets are needed for importer, then $(pCI \times TpIc)$; if no additional pallets are needed then (0, 0).

Single SKU Total Costs for an Excess Palletized Container Full Charged

$$Cpec + DCEc + SCc + DCIc + Cuepc = TCepc^*(\$) \qquad (4\text{-}12\text{-}3)$$

4.2.1 Single SKU Cost Meeting Daily Demand

Once total shipping and handling costs per container have been calculated, and container demand is known, costs to meet daily demand for floor loaded boxes and palletized boxes can be determined. Both partial and full charged excess containers are included in the calculation. Total cost per full container was determined in Equation 4-7-2 and 4-8-2 for floor loaded containers and containers with contents unitized, respectively. From Equations 4-3 and 4-4 the number of containers per day was determined for floor loaded containers and containers with contents unitized, respectively. From this, the number of full containers is known. For each loading method, the total cost per full container is either added to the cost of an excess container charged partial, (shown in Equations 4-13-2 and 4-14-2 for boxes floor loaded and boxes unitized on pallets, respectively), or to the cost of an excess container charged in full (shown in Equations 4-13-3 and 4-14-3 for boxes floor loaded and boxes unitized on pallets, respectively). The result is the total cost for containers per day for partially charged or fully charged excess containers for each loading method.

Table 4-13 Single SKU Cost Meeting Demand Floor Loaded Defined

Abbreviation	Definition
$TCFfc$	Total (Shipping and Handling) Costs per Full Floor Loaded Container
$NFcfd$	Number of Full Containers Floor Loaded per Day
$TCFcfd$	Total Cost for Full Containers Floor Loaded per Day
$TCefc$	Total (Shipping and Handling) Costs for an Excess Floor Loaded Container (used only if a partial container exists to meet demand and is charged partial shipping/ transport costs, and partial labor)
$TCfcd$	Total (Shipping and Handling) Costs for Floor Loaded Containers per Day (Excess Containers are charged partial shipping/transport, and partial labor)
$TCefc^*$	Total (Shipping and Handling) Costs for an Excess Floor Loaded Container (used only if a partial container exists to meet demand and is charged full shipping/ transport costs, and partial labor)
$TCfcd^*$	Total (Shipping and Handling) Costs for Floor Loaded Containers per Day (Excess Containers are charged full shipping/transport, and partial labor)

Single SKU Total Cost for Full Containers Floor Loaded per Day

$$TCFfc \times NFcfd = TCFcfd\ (\$) \tag{4-13-1}$$

Single SKU Total Costs for Floor Loaded Containers per Day Partial Charge

$$TCFcfd + TCefc\ = TCfcd\ (\$) \tag{4-13-2}$$

Single SKU Total Costs for Floor Loaded Containers per Day Charged in Full

$$TCFcfd + TCefc^{*} = TCfcd^{*}(\$) \tag{4-13-3}$$

Table 4-14 Single SKU Cost Meeting Demand Palletized Defined

Abbreviation	Definition
$TCFpc$	Total (Shipping and Handling) Costs per Full Palletized Container
$NFcpd$	Number of Full Containers Palletized per Day
$TCFcpd$	Total Cost for Full Containers Palletized per Day
$TCepc$	Total (Shipping and Handling) Costs for an Excess Palletized Container (used only if a partial container exists to meet demand and is charged partial shipping/ transport costs, and partial labor)
$TCpcd$	Total (Shipping and Handling) Costs for Palletized Containers per Day (Excess Containers are charged partial shipping/transport, and partial labor)
$TCepc^{*}$	Total (Shipping and Handling) Cost for an Excess Palletized Container (used only if a partial container exists to meet demand and is charged full shipping/ transport costs, and partial labor)
$TCpcd^{*}$	Total (Shipping and Handling) Costs for Palletized Containers per Day (Excess Containers are charged full shipping/transport, and partial labor)

Single SKU Total Cost for Full Containers Palletized per Day

$$TCFpc \times NFcpd = TCFcpd\ (\$) \tag{4-14-1}$$

Single SKU Total Costs for Palletized Containers per Day Partial Charge

$$TCFcpd + TCepc = TCpcd\ (\$) \tag{4-14-2}$$

Single SKU Total Costs for Palletized Containers per Day Charged in Full

$$TCFcpd + TCepc^{*} = TCpcd\ ^{*}(\$) \tag{4-14-3}$$

4.2.2 Single SKU Net Value Meeting Daily Demand

The following equations find the daily net value for floor loaded and palletized containers by removing the shipping and handling charges from each. The product values per day for the two loading methods were determined in Equations 4-5 and 4-6 for floor loaded containers and containers with contents unitized, respectively. For both loading methods, product value per day is subtracted from the total costs of containers meeting daily demand (considers partial and full charged containers).

Table 4-15 Single SKU Net Value Floor Loaded Meeting Demand Defined

Abbreviation	Definition
$PVdf$	Product Value per Day Floor Loaded
$TCfcd$	Total (Shipping and Handling) Costs for Floor Loaded Containers per Day (Excess Containers are charged partial shipping/transport, and partial labor)
nVf	Net Value Floor Loaded
$TCfcd^*$	Total (Shipping and Handling) Costs for Floor Loaded Containers per Day (Excess Containers are charged full shipping/transport, and partial labor)

Single SKU Net Value Floor Loaded Partial Charge

$$PVdf - TCfcd = nVf \ (\$) \qquad (4\text{-}15\text{-}1)$$

If excess container space exists and costs cannot be absorbed by other products then:

Single SKU Net Value Floor Loaded Charged in Full

$$PVdf - TCfcd^* = nVf \ (\$) \qquad (4\text{-}15\text{-}2)$$

Table 4-16 Single SKU Net Value Palletized Meeting Demand Defined

Abbreviation	Definition
$PVdp$	Product Value per Day Palletized
$TCpcd$	Total (Shipping and Handling) Costs for Palletized Containers per Day (Excess Containers are charged partial shipping/transport, and partial labor)
nVp	Net Value Palletized
$TCpcd^*$	Total (Shipping and Handling) Costs for Palletized Containers per Day (Excess Containers are charged full shipping/transport, and partial labor)

Single SKU Net Value Palletized Partial Charge

$$PVdp - TCpcd = nVp \ (\$) \qquad (4\text{-}16\text{-}1)$$

If excess container space exists and costs cannot be absorbed by other products then:

Single SKU Net Value Palletized Charged in Full

$$PVdp - TCpcd^* = nVp \ (\$) \qquad (4\text{-}16\text{-}2)$$

4.2.3 Single SKU Net Value Delta Meeting Daily Demand

The net value delta (cost savings benefit) is obtained by subtracting the net value palletized from net value floor loaded, which allows a decision to be made based on the shipping and handling costs to meet demand. If the calculated answer is positive, a cost savings benefit exists for floor loading and not for palletizing. If the calculated answer is negative, a cost savings benefit exists for palletizing and not floor loading. A positive number indicates it is less expensive by the amount observed to floor load. A negative number indicates it is less expensive by the amount observed to palletize.

Table 4-17 Single SKU Net Value Delta Meeting Demand Defined

Abbreviation	Definition
nVf	Net Value Floor Loaded
nVp	Net Value Palletized
Bfp	Benefit of Floor Loading or Palletizing

Single SKU Cost savings Benefit of Floor Loading or Palletizing

$$nVf - nVp = Bfp \text{ (\$)} \tag{4-17}$$

4.2.4 Single SKU Dock Door Capacity Meeting Daily Demand

It was found that containerships have unpredictable arrival times. Assuming containers arrive all at one time, or the facility unloads an array of products from various importers, a calculation to determine the number of receiving dock doors needed to receive demand can be made. If enough doors are available then the number of containers to be received can be equal to the doors needed. For certain facilities, the number of doors is limited. This results a container to be moved from a dock door, so another can be unloaded. To determine the number of doors needed to meet demand, the time to unload a container is added to the time to move a container (if applicable). The result is multiplied by the number of containers needed to meet demand and divided by the available hours per receiving dock door, as shown in Equation 4-18-1 for boxes floor loaded and Equation 4-19-1 for boxes unitized on pallets.

For fast moving boxed products, the goal may be to get as many boxes in during work hours (maximize throughput). To determine the maximum number of containers that can be unloaded per door when demand is not a consideration, the available hours per receiving dock door is divided by the time to unload (including time to move a container if applicable), shown in Equation 4-18-2 for boxes floor loaded and Equation 4-19-2. A product value to cost comparison can be made when demand is not a consideration by subtracting the total costs per door from the total value per door for each loading method, which results a net value for each loading method. By comparing the net values for each loading method (subtracting net value palletized from net value floor loaded) a cost based decision can be made based on the amount of product received.

Table 4-18 Single SKU Dock Door Capacity Floor Loaded Meeting Demand Defined

Abbreviation	**Definition**
$utfc$	Unloading Time for a Floor Loaded Container
tMc	Time to Move a Container
$Tfcd$	Total Number of Floor Loaded Containers Needed per Day
AHR	Available Hours per Receiving Door
$TRdf$	Total Number of Receiving Doors Needed per Day to Meet Daily Container Demand Floor Loaded
$mcdf$	Maximum Containers per Day per Door Floor Loaded
Vfc	Value of Floor Loaded Container
$TCfc$	Total (Shipping and Handling) Costs per Floor Loaded Container
nVf	Net Value Floor Loaded

To determine the number of doors required meeting demand to unload desired amount of containers then,

Single SKU Receiving Dock Doors Needed to Meet Demand Floor Loaded

$$(utfc\ + (tMc\ if\ applicable)) \times (Tfcd) \div AHR = TRdf\ (Doors) \tag{4-18-1}$$

Previous dock door calculations consider that demand must be met and not exceeded. For facilities not concerned with meeting demand, but rather to maximize throughput, the calculation can be altered to accommodate this scenario.

Single SKU Maximum Number of Containers per Door Floor Loaded

$$(AHR \div (utfc + tMc)) = mcdf\ (Containers/Door) \qquad (4\text{-}18\text{-}2)$$

To determine net value when demand is not a consideration,

Single SKU Net Value Floor Loaded Unrestricted Demand

$$(Vfc \times mcdf) - (TCfc \times mcdf) = nVf\ (\$) \qquad (4\text{-}18\text{-}3)$$

Table 4-19 Single SKU Dock Door Capacity Palletized Meeting Demand Defined

Abbreviation	Definition
$utpc$	Unloading Time for a Palletized Container
tMc	Time to Move Containers
$Tpcd$	Total Number of Palletized Containers Needed per Day
AHR	Available Hours per Receiving Dock Door
$TRdp$	Total Number of Receiving Doors Needed per Day to Meet Daily Container Demand Palletized
$mcdp$	Maximum Containers per Day per Door Palletized
Vpc	Value of Palletized Container
$TCpc$	Total (Shipping and Handling) Costs per Palletized Container
nVp	Net Value Palletized

To determine the number of doors required to meet demand, then,

Single SKU Receiving Dock Doors Needed to Meet Demand Palletized

$$\big(utpc + (tMc\ \ if\ applicable)\big) \times (Tpcd) \div AHR = TRdp\ (Doors) \qquad (4\text{-}19\text{-}1)$$

Previous dock door equations consider that demand must be met not exceeded. For facilities not concerned with meeting demand, but rather to maximize throughput, the calculation can be altered to accommodate this scenario.

Single SKU Maximum Number of Containers per Door Palletized

$$(AHR \div (utpc + tMc)) = mcdp\ (Containers/Door) \qquad (4\text{-}19\text{-}2)$$

To determine a benefit when demand is not a consideration, then,

Single SKU Net Value Palletized Unrestricted Demand

$$(Vpc \times mcdp) - (TCpc \times mcdp) = nVp\ (\$) \qquad (4\text{-}19\text{-}3)$$

4.3 Mixed SKU Containers

Figure 4-1 and 4-2 were constructed in MaxLoad (a similar software to TOPS, but allows various dimension boxes per container) to illustrate mixed SKU containers. In the example, three SKUs with varying dimensions and quantity are portrayed. To calculate, arrange SKUs into sections within the container as shown in Figure 4-1. Determine the total number of boxes needed, or maximum fit per container floor loaded. Place single SKU products on best fit pallets, for product and destined supply chain. Complete for remaining SKUs in the container. Figure 4-2 illustrates palletized boxes in the container. For each SKU, the pallet configuration is the same.

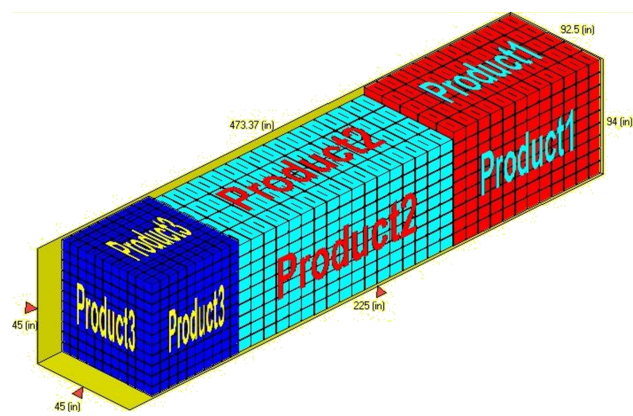

Figure 4-1 Mixed SKU Floor Loaded Example

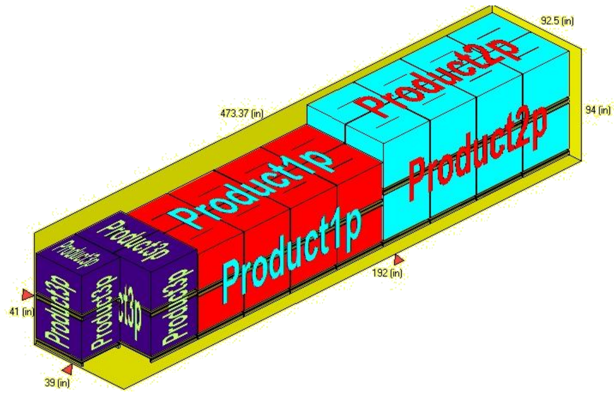

Figure 4-2 Mixed SKU Palletized Example

4.3.1 Mixed SKU Container Value

Inputting the number of boxes for each SKU floor loaded and palletized obtained from MaxLoad or a similar software package, and an individual box value for each SKU, allows for container values to be calculated on a SKU basis. Container value is calculated the same for mixed SKU containers as single SKU containers. However, the value of each SKU needs to be determined as shown in Equations 4-20-1 and 4-20-2 for boxes floor loaded and in Equations 4-21-1 and 4-21-2 for boxes unitized on pallets. Like the results obtained from TOPS, MaxLoad results are assumed full containers for either floor loaded boxes or palletized boxes (unusable space due to box size or weight in containers is likely).

Table 4-20 Mixed SKU Container Value Floor Loaded Defined

Abbreviation	Definition
$Nfbc_1$	Number of Floor Loaded Boxes per Full Container SKU$_1$
$Nfbc_n$	Number of Floor Loaded Boxes per Full Container SKU $_n$
Vb_1	Value of Individual Box SKU$_1$
Vb_n	Value of Individual Box SKU $_n$
Vfc_1	Total Value of Floor Loaded Container SKU$_1$
Vfc_n	Total Value of Floor Loaded Container SKU $_n$

$\boldsymbol{SKU_1}$

Mixed SKU Container Value Floor Loaded SKU$_1$

$$Nfbc_1 \times Vb_1 = Vfc_1 \text{ (\$)} \tag{4-20-1}$$

$\boldsymbol{SKU_n}$

Mixed SKU Container Value Floor Loaded SKU$_n$

$$Nfbc_n \times Vb_n = Vfc_n \text{ (\$)} \tag{4-20-2}$$

Table 4-21 Mixed SKU Container Value Palletized Defined

Abbreviation	Definition
$Nbpc_1$	Number of Boxes Palletized per Full Container SKU$_1$
$Nbpc_n$	Number of Boxes Palletized per Full Container SKU $_n$
Vb_1	Value of Individual Box SKU$_1$
Vb_n	Value of Individual Box SKU $_n$
Vpc_1	Value of Palletized Container SKU$_1$
Vpc_n	Value of Palletized Container SKU $_n$

$\boldsymbol{SKU_1}$

Mixed SKU Container Value Palletized SKU$_1$

$$Nbpc_1 \times Vb_1 = Vpc_1 \text{ (\$)} \tag{4-21-1}$$

$\boldsymbol{SKU_n}$

Mixed SKU Container Value Palletized SKU$_n$

$$Nbpc_n \times Vb_n = Vpc_n \text{ (\$)} \tag{4-21-2}$$

4.3.2 Mixed SKU Containers Volume Needed to Meet Daily Demand

To determine the number of containers required, box demand per day needs to be known. Box demand per day floor loaded needs to equal boxes required per day palletized for each SKU. Since each SKU has varying dimensions, container demand is derived using volume. Volume is considered to prevent higher costs for large quantities of small boxes that occupy less space. The costs are proportional to the space occupied. For boxes floor loaded, the total box volume per container for each SKU is determined by multiplying the individual box volume of the specified SKU by the number of boxes of the specified SKU, as shown in Equations 4-22-1 and 4-22-2. For boxes unitized on pallets, the total box and pallet volume per container is determined by multiplying the volume of the unit load of the specified SKU (including the pallet) by the number of unit loads (pallets) per full container of the specified SKU, as shown in Equations 4-23-1 and 4-23-2.

By summing the volumes of each SKU, the useable container volumes are determined for each loading method, shown in Equations 4-22-3 and 4-22-4 for boxes floor loaded, and in Equations 4-23-3 and 4-23-4 for boxes unitized on pallets.

The total box volume per day for floor loading is obtained by multiplying the box demand per day by the individual box volume for a specified SKU, as shown in Equations 4-22-5 and 4-22-7. For boxes unitized on pallets, first the number of boxes per day is divided by the number of boxes per pallet for each SKU, as shown in Equations 4-23-5 and 4-23-8. The total box volume per day for boxes unitized on pallets is obtained by multiplying the number of pallets per day by the unit load volume (including pallet volume). Equations 4-23-6 and 4-23-9 display these calculations.

Dividing the total box volume per day, or the total box and pallet volume per day by the useable container volume obtained for each loading method results the amount of container volume needed per day (occupied container volume per day), as displayed in Equations 4-22-6 and 4-22-8 for floor loaded boxes, and in Equations 4-23-7 and 4-23-10 for boxes unitized on pallets. Summing the occupied container volumes obtained for each SKU, for each loading method results the number of containers to meet daily demand, as shown in Equation 4-22-9 for boxes floor loaded and Equation 4-23-11 for boxes unitized on pallets.

Table 4-22 Mixed SKU Containers to Meet Demand Floor Loaded Defined

Abbreviation	Definition
bv_1	Box Volume SKU$_1$
bv_n	Box Volume SKU $_n$
$Nfbc_1$	Number of Floor Loaded Boxes per Full Container SKU$_1$
$Nfbc_n$	Number of Floor Loaded Boxes per Full Container SKU $_n$
$Tbvc_1$	Box Volume per Container SKU$_1$
$Tbvc_n$	Total Box Volume per Container SKU $_n$
$Tbvc_i$	Sum of Total Box Volumes per Container SKU$_{1\ldots n}$
$ucvbf$	Useable Container Volume for Boxes Floor Loaded
Nbd_1	Number of Boxes Needed per Day SKU$_1$
Nbd_n	Number of Boxes Needed per day SKU $_n$
$Tbvd_1$	Total Box Volume Needed per day SKU$_1$
$Tbvd_n$	Total Box Volume Needed per Day SKU $_n$
$Ocvbd_1$	Occupied Container Volume of Boxes per day SKU$_1$
$Ocvbd_n$	Occupied Container Volume of Boxes per day SKU $_n$
$Ocvbd_i$	Sum of the Occupied Container Volume of Boxes per day SKU $_i$

$\boldsymbol{SKU_{1\ldots n}}$

Mixed SKU Total Box Volume per Container Floor Loaded SKU$_1$

$$bv_1 \times Nfbc_1 = Tbvc_1\ (Volume) \tag{4-22-1}$$

Mixed SKU Total Box Volume per Container Floor Loaded SKU$_n$

$$bv_n \times Nfbc_n = Tbvc_n\ (Volume) \tag{4-22-2}$$

Mixed SKU Total Box Volume per Container Floor Loaded SKU$_{1\ldots n}$

$$Tbvc_1 + \cdots + Tbvc_n = \sum_{i=1}^{n} Tbvc_i\ \ (Volume) \tag{4-22-3}$$

Mixed SKU Useable Container Volume of Boxes Floor Loaded

$$\sum_{i=1}^{n} Tbvc_i = ucvbf\ \ (Volume) \tag{4-22-4}$$

$\boldsymbol{SKU_1}$

Mixed SKU Total Box Volume per Day Floor Loaded SKU$_1$

$$Nbd_1 \times bv_1 = Tbvd_1\ (Volume) \tag{4-22-5}$$

Mixed SKU Occupied Container Volume per Day Floor Loaded SKU$_1$

$$Tbvd_1 \div ucvbf = Ocvbd_1 \ (Volume\%) \tag{4-22-6}$$

$\boldsymbol{SKU_n}$

Mixed SKU Total Box Volume per Day Floor Loaded SKU$_n$

$$Nbd_n \times bv_n = Tbvd_n(Volume) \tag{4-22-7}$$

Mixed SKU Occupied Container Volume per Day Floor Loaded SKU$_n$

$$Tbvd_n \div ucvbf = Ocvbd_n \ (Volume\%) \tag{4-22-8}$$

$\boldsymbol{SKU_{1\ldots n}}$

Mixed SKU Number of Containers to Meet Demand Floor Loaded

$$Ocvbd_1 + \cdots + Ocvbd_n = \sum_{i=1}^{n} Ocvbd_i \ (Containers) \tag{4-22-9}$$

Table 4-23 Mixed SKU Containers to Meet Demand Palletized Defined

Abbreviation	Definition
pbv_1	Pallet and Box Volume SKU$_1$
pbv_n	Pallet and Box Volume SKU $_n$
Npc_1	Number of Pallets per Full Container SKU$_1$
Npc_n	Number of Pallets per Full Container SKU $_n$
$Tpbvc_1$	Total Pallet and Box Volume per Container SKU$_1$
$Tpbvc_n$	Total Pallet and Box Volume per Container SKU $_n$
$Tpbvc_i$	Sum of Total Pallet and Box Volumes per Container SKU$_{1\ldots n}$
$ucvpb$	Useable Container Volume for Palletized Boxes
Nbd_1	Number of Boxes Needed per Day SKU$_1$
Nbd_n	Number of Boxes Needed per day SKU $_n$
$Tpbvd_1$	Total Pallet and Box Volume Needed per Day SKU$_1$
$Tpbvd_n$	Total Pallet and Box Volume Needed per Day SKU $_n$
$Ocvpbd_1$	Occupied Container Volume of Pallets and Boxes per day SKU$_1$
$Ocvpbd_n$	Occupied Container Volume of Pallets and Boxes per day SKU $_n$
$Ocvpbd_i$	Sum of the Occupied Container Volume of Pallets and Boxes per day SKU $_i$

$\boldsymbol{SKU_{1\ldots n}}$

Mixed SKU Total Box Volume per Container Palletized SKU$_1$

$$pbv_1 \times Npc_1 = Tpbvc_1 \ (Volume) \tag{4-23-1}$$

Mixed SKU Total Box Volume per Container Palletized SKU_n

$$pbv_n \times Npc_n = Tpbvc_n \ (Volume) \tag{4-23-2}$$

Mixed SKU Total Box Volume per Container Palletized $\text{SKU}_{1\ldots n}$

$$Tpbvc_1 + \cdots + Tpbvc_n = \sum_{i=1}^{n} Tpbvc_i \ (Volume) \tag{4-23-3}$$

Mixed SKU Useable Container Volume of Boxes Palletized

$$\sum_{i=1}^{n} Tpbvc_i = ucvpb \ (Volume) \tag{4-23-4}$$

$\boldsymbol{SKU_1}$

Mixed SKU Number of Pallets to Meet Demand SKU_1

$$(Nbd_1 \div Nbp_1) = Npd_1 \ (Pallets) \tag{4-23-5}$$

*If $Nbd_1 \div Nbp_1$ is not a whole number, round up to the nearest whole number.

Mixed SKU Total Box Volume per Day Palletized SKU_1

$$Npd_1 \times pbv_1 = Tpbvd_1 \ (Volume) \tag{4-23-6}$$

Mixed SKU Occupied Container Volume per Day Palletized SKU_1

$$Tpbvd_1 \div ucvpb = Ocvpbd_1 \ (Volume(\%) \tag{4-23-7}$$

$\boldsymbol{SKU_n}$

Mixed SKU Number of Pallets to Meet Demand SKU_n

$$(Nbd_n \div Nbp_n) = Npd_n \ (Pallets) \tag{4-23-8}$$

*If $Nbd_n \div Nbp_n$ is not a whole number, round up to the nearest whole number.

Mixed SKU Total Box Volume per Day Palletized SKU_n

$$Npd_n \times pbv_n = Tpbvd_n (Volume) \tag{4-23-9}$$

Mixed SKU Occupied Container Volume per Day Palletized SKU_n

$$Tpbvd_n \div ucvpb = Ocvpbd_n \ (Volume \ (\%) \tag{4-23-10}$$

$\boldsymbol{SKU_{1\ldots n}}$

Mixed SKU Number of Containers to Meet Demand Palletized

$$Ocvpbd_1 + \cdots + Ocvpbd_n = \sum_{i=1}^{n} Ocvpbd_i \ (Containers) \tag{4-23-11}$$

4.3.3 Mixed SKU Product Value Meeting Daily Demand

Product value per day for the two loading methods is obtained by multiplying the number of boxes to meet demand by the individual box value. Equations 4-24-1 and 4-24-2 display the calculations for floor loaded boxes for each SKU. Equations 4-25-1 and 4-25-2 display the calculations for boxes unitized on pallets for each SKU.

Table 4-24 Mixed SKU Product Value Floor Loaded Meeting Demand Defined

Abbreviation	Definition
Nbd_1	Number of Boxes needed per Day SKU_1
Nbd_n	Number of Boxes needed per Day SKU_n
Vb_1	Value of Individual Box SKU_1
Vb_n	Value of Individual Box SKU_n
$PVdf_1$	Product Value per Day Floor Loaded SKU_1
$PVdf_n$	Product Value per Day Floor Loaded SKU_n

$\boldsymbol{SKU_1}$

Mixed SKU Product Value per Day Floor Loaded SKU_1

$$Nbd_1 \times Vb_1 = PVdf_1(\$) \tag{4-24-1}$$

$\boldsymbol{SKU_n}$

Mixed SKU Product Value per Day Floor Loaded SKU_n

$$Nbd_n \times Vb_n = PVdf_n\ (\$) \tag{4-24-2}$$

Table 4-25 Mixed SKU Product Value Palletized Meeting Demand Defined

Abbreviation	Definition
Nbd_1	Number of Boxes needed per Day SKU_1
Nbd_n	Number of Boxes needed per Day SKU_n
Vb_1	Value of Individual Box SKU_1
Vb_n	Value of Individual Box SKU_n
$PVdp_1$	Product Value per Day Palletized SKU_1
$PVdp_n$	Product Value per Day Palletized SKU_n

$\boldsymbol{SKU_1}$

Mixed SKU Product Value per Day Palletized SKU$_1$

$$Nbd_1 \times Vb_1 = PVdp_1(\$) \tag{4-25-1}$$

$\boldsymbol{SKU_n}$

Mixed SKU Product Value per Day Palletized SKU$_n$

$$Nbd_n \times Vb_n = PVdp_n\ (\$) \tag{4-25-2}$$

4.3.4 Mixed SKU Costs per Container

The next step is to determine shipping and handling costs for each SKU per container. Labor cost per SKU to load floor loaded boxes in a container is based off of the labor cost load all floor loaded boxes in a container. The total number of boxes per container is obtained by summing the number of boxes for each SKU as shown in Equation 4-26-1. The labor cost for a floor loaded container is divided by the total number of boxes per container, and the result is multiplied by the number of boxes for the specified SKU, shown in Equations 4-26-2 and 4-26-9.

Unlike single SKU containers, mixed SKU containers consider the number of pallets to calculate labor costs for containers with contents palletized, as determined in Equation 4-27-1. Labor to move boxes on pallets is assumed to be the same for all pallets in a container, regardless of the box size or box contents. The difference in labor cost per SKU for boxes unitized on pallets is determined by the number of pallets of the specified SKU. The cost to load pallets in a container per SKU is determined by dividing the labor cost to unload a full palletized container by the number of pallets per container. The result is multiplied by the number of pallets of the specified SKU, and then added to the total cost of pallets per container (including phytosanitation costs). The calculations for the various SKUs are shown in Equations 4-27-2 and 4-27-9.

Using total box volume per container for floor loaded boxes obtained in Equation 4-22-1 and 4-22-2 and the useable container volume obtained in Equation 4-22-4, the occupied container volume for boxes floor loaded per container is obtained. The calculations to determine the occupied container volume for the varying SKUs floor loaded is shown in Equations 4-26-3 and 4-26-10.

Dividing the total pallet and box volume per container for the varying SKUs obtained from Equations 4-23-1 and 4-23-2 by the useable pallet and box container volume determined in Equation 4-23-4, results the occupied container volume for boxes unitized on pallets. Equations 4-27-3 and 4-27-10 display the calculations for the varying SKUs.

The export drayage, shipping, and import drayage costs per SKU are obtained by multiplying the costs and the occupied box volume for the floor loaded container. Equations 4-26-4 through 4-26-6 demonstrate the calculations for SKU_1. Equations 4-26-11 through 4-26-13 provide the calculation for $SKU_{n.}$ Containers with contents palletized use a similar calculation, but consider both the pallet and box volume. Equations 4-27-4 through 4-27-6 provide the calculations for $SKU_{1.}$ The additional SKU is demonstrated in Equations 4-27-11 through 4-27-13.

The cost of unloading floor loaded boxes from a container is determined the same as loading labor cost, but including the cost of pallets, as shown in Equations 4-26-7 and 4-26-14. The unloading cost for boxes unitized on pallets is the same as the loading cost for boxes unitized on pallets, without the phytosanitation costs. Additional pallets on the import side are included, in the case that the pallet configuration is changed once unloaded. The calculations for the varying SKUs are displayed in Equations 4-27-7 and 4-27-14.

The total cost per container is obtained by summing the loading cost, export drayage cost, shipping cost, import drayage cost, and unloading cost for the two loading methods on a SKU basis. The calculations for floor loaded boxes are shown in Equation 4-26-8 and 4-26-15. Equations 4-27-8 and 4-27-15 demonstrate the total cost per container calculation for boxes unitized on pallets.

Table 4-26 Mixed SKU Costs Floor Loaded Container Defined

Abbreviation	Definition
$Nfbc_1$	Number of Floor Loaded Boxes per Full Container SKU$_1$
$Nfbc_n$	Number of Floor Loaded Boxes per Full Container SKU $_n$
$Nfbc_i$	Sum of the Number of Floor Loaded Boxes per Full Container SKU $_{1\ldots n}$
$LCfbc$	Labor Cost to Floor Load Boxes in a Container
$LCfbc_1$	Labor Cost to Floor Load Boxes in a Container SKU$_1$
$LCfbc_n$	Labor Cost to Floor Load Boxes in a Container SKU $_n$
$Tbvc_1$	Total Box Volume per Container SKU$_1$
$Tbvc_n$	Total Box Volume per Container SKU $_n$
$ucvbf$	Useable Container Volume for Boxes Floor Loaded
$Ocvb_1$	Occupied Container Volume of Boxes SKU$_1$
$Ocvb_n$	Occupied Container Volume of Boxes SKU $_n$
$DCEc$	Drayage Cost Exporter per Container
$DCEc_1$	Drayage Cost Exporter SKU$_1$
$DCEc_n$	Drayage Cost Exporter SKU $_n$
SCc	Shipping Cost per Container
SCc_1	Shipping Cost per Container SKU$_1$
SCc_n	Shipping Cost per Container SKU $_n$
$DCIc$	Drayage Cost Importer per Container
$DCIc_1$	Drayage Cost Importer per Container SKU$_1$
$DCIc_n$	Drayage Cost Importer per Container SKU $_n$
$LCufbc$	Labor Cost to Unload Floor Loaded Boxes from a Container
$NbpI_1$	Number of Boxes per Pallet Importer SKU$_1$
$NbpI_n$	Number of Boxes per Pallet Importer SKU $_n$
pCI_1	Pallet Cost Importer SKU$_1$
pCI_n	Pallet Cost Importer SKU $_n$
$Cufc_1$	Costs (labor and pallets) to Unload a Floor Loaded Container SKU$_1$
$Cufc_n$	Costs (labor and pallets) to Unload a Floor Loaded Container SKU $_n$
$TCFfc_1$	Total (Shipping and Handling) Costs per Full Floor Loaded Container SKU$_1$
$TCFfc_n$	Total (Shipping and Handling) Costs per Full Floor Loaded Container SKU $_n$

$SKU_{1 \dots n}$

Mixed SKU Total Number of Boxes Floor Loaded per Full Container

$$Nfbc_1 + \cdots + Nfbc_n = \sum_{i=1}^{n} Nfbc_i \ (Boxes) \quad (4\text{-}26\text{-}1)$$

SKU_1

Mixed SKU Loading Cost to Floor Load Boxes per Container SKU$_1$

$$\left(LCfbc \div \sum_{i=1}^{n} Nfbc_i\right) \times Nfbc_1 = LCfbc_1 \ (\$) \quad (4\text{-}26\text{-}2)$$

Mixed SKU Occupied Container Volume for Boxes Floor Loaded SKU$_1$

$$Tbvc_1 \div ucvbf = Ocvb_1 \ (Volume\%) \quad (4\text{-}26\text{-}3)$$

Mixed SKU Drayage Cost Exporter Floor Loaded SKU$_1$

$$DCEc \times Ocvb_1 = DCEc_1 \ (\$) \quad (4\text{-}26\text{-}4)$$

Mixed SKU Shipping Cost Floor Loaded SKU$_1$

$$SCc \times Ocvb_1 = SCc_1(\$) \quad (4\text{-}26\text{-}5)$$

Mixed SKU Drayage Cost Importer Floor Loaded SKU$_1$

$$DCIc \times Ocvb_1 = DCIc_1(\$) \quad (4\text{-}26\text{-}6)$$

Mixed SKU Unloading Cost Floor Loaded SKU$_1$

$$\left(\left(LCufbc \div \sum_{i=1}^{n} Nfbc_i\right) \times Nfbc_1\right) + \left(\left(Nfbc_1 \div NbpI_1\right) \times PCI_1\right) = Cufc_1(\$) \quad (4\text{-}26\text{-}7)$$

* If $Nfbc_1 \div NbpI_1$ is not a whole number, roundup to the nearest whole number

Mixed SKU Total Cost per Full Floor Loaded Container SKU$_1$

$$LCfbc_1 + DCEc_1 + SCc_1 + DCIc_1 + Cufc_1 = TCFfc_1(\$) \quad (4\text{-}26\text{-}8)$$

SKU_n

Mixed SKU Loading Cost to Floor Load Boxes per Container SKU$_n$

$$\left(LCfbc \div \sum_{i=1}^{n} Nfbc_i\right) \times Nfbc_n = LCfbc_n \ (\$) \quad (4\text{-}26\text{-}9)$$

Occupied Container Volume for Boxes Floor Loaded SKU$_n$

$$Tbvc_n \div ucvbf = Ocvb_n \ (Volume\%) \quad (4\text{-}26\text{-}10)$$

Drayage Cost Exporter Floor Loaded SKU$_n$

$$DCEc \times Ocvb_n \; = \; DCEc_n \; (\$) \tag{4-26-11}$$

Shipping Cost Floor Loaded SKU$_n$

$$SCc \times Ocvb_n \; = \; SCc_n (\$) \tag{4-26-12}$$

Drayage Cost Importer Floor Loaded SKU$_n$

$$DCIc \times Ocvb_n \; = \; DCIc_n (\$) \tag{4-26-13}$$

Mixed SKU Unloading Cost Floor Loaded SKU$_n$

$$\left((LCufbc \div \sum_{i=1}^{n} Nfbc_i) \times Nfbc_n\right) + ((Nfbc_n \div NbpI_n) \times PCI_n) = \; Cufc_n (\$) \tag{4-26-14}$$

Mixed SKU Total Cost per Full Floor Loaded Container SKU$_n$

$$LCfbc_n + DCEc_n \; + \; SCc_n + \; DCIc_n \; + \; Cufc_n = \; TCFfc_n (\$) \tag{4-26-15}$$

Table 4-27 Mixed SKU Palletized Costs per Container Defined

Abbreviation	Definition
Npc_1	Number of Pallets per Full Container SKU$_1$
Npc_n	Number of Pallets per Full Container SKU $_n$
Npc_i	Sum of the Number of Pallets per Full Container SKU $_{1...n}$
$LCpc$	Labor Cost to Load Pallets (or to load boxes onto pallets) in a Container
pCE_1	Pallet Cost Exporter SKU$_1$
pCE_n	Pallet Cost Exporter SKU $_n$
pTC	Pallet Treatment Cost
$Nbpc_1$	Number of Boxes Palletized per Container SKU$_1$
$Nbpc_n$	Number of Boxes Palletized per Container SKU $_n$
$NbpE_1$	Number of Boxes per Pallet Exporter SKU$_1$
$NbpE_n$	Number of Boxes per Pallet Exporter SKU $_n$
Cpc_1	Cost (labor and pallets) to Load Palletized Boxes in a Container SKU$_1$
Cpc_n	Cost (labor and pallets) to Load Palletized Boxes in a Container SKU $_n$
$Tpbvc_1$	Total Pallet and Box Volume per Container SKU$_1$
$Tpbvc_n$	Total Pallet and Box Volume per Container SKU $_n$
$ucvpb$	Useable Container Volume for Pallets and Boxes
$Ocvpb_1$	Occupied Container Volume of Pallets and Boxes SKU$_1$
$Ocvpb_n$	Occupied Container Volume of Pallets and Boxes SKU $_n$
$DCEc$	Drayage Cost Exporter per Container
$DCEc_1$	Drayage Cost Exporter SKU$_1$
$DCEc_n$	Drayage Cost Exporter SKU $_n$
SCc	Shipping Cost per Container
SCc_1	Shipping Cost SKU$_1$ per Container
SCc_n	Shipping Cost SKU $_n$ per Container
$DCIc$	Drayage Cost Importer per Container
$DCIc_1$	Drayage Cost Importer SKU$_1$ per Container
$DCIc_n$	Drayage Cost Importer SKU $_n$ per Container
pCI_1	Pallet Cost Importer SKU$_1$
pCI_n	Pallet Cost Importer SKU $_n$
$TpIc_1$	Total Number of Pallets needed Importer per Container SKU$_1$
$TpIc_n$	Total Number of Pallets needed Importer per Container SKU $_n$
$Cupc_1$	Costs (labor and pallets) to Unload a Palletized Container SKU$_1$
$Cupc_n$	Costs (labor and pallets) to Unload a Palletized Container SKU $_n$
$TCFpc_1$	Total Cost for Full Containers Palletized SKU$_1$
$TCFpc_n$	Total Cost for Full Containers Palletized SKU $_n$

$\boldsymbol{SKU_{1\dots n}}$

Mixed SKU Total Number of Pallets per Full Container

$$Npc_1 + \cdots + Npc_n = \sum_{i=1}^{n} Npc_i \quad (Pallets) \tag{4-27-1}$$

$\boldsymbol{SKU_1}$

Mixed SKU Loading Cost for Pallets per Container SKU_1

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times Npc_1\right) + ((pCE_1 + pTC) \times (Nbpc_1 \div NbpE_1)) = Cpc_1(\$) \tag{4-27-2}$$

* If $Nbpc_1 \div NbpE_1$ is not a whole number, roundup to the nearest whole number

Mixed SKU Occupied Container Volume of Pallets and Boxes SKU_1

$$Tpbvc_1 \div ucvpb = Ocvpb_1 \ (Volume\%) \tag{4-27-3}$$

Mixed SKU Drayage Cost Exporter Palletized SKU_1

$$DCEc \times Ocvpb_1 = DCEc_1 \ (\$) \tag{4-27-4}$$

Mixed SKU Shipping Cost Palletized SKU_1

$$SCc \times Ocvpb_1 = SCc_1(\$) \tag{4-27-5}$$

Mixed SKU Drayage Cost Importer Palletized SKU_1

$$DCIc \times Ocvpb_1 = DCIc_1(\$) \tag{4-27-6}$$

Mixed SKU Unloading Cost Palletized SKU_1

$$\left((LCupc \div \sum_{i=1}^{n} Npc_i) \times Npc_1\right) + (pCI_1 \times TpIc_1) = Cupc_1 \ (\$) \tag{4-27-7}$$

*If additional pallets are needed for the importer, then$(pCI_1 \times TpIc_1)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost per Full Palletized Container SKU_1

$$Cpc_1 + DCEc_1 + SCc_1 + DCIc_1 + Cupc_1 = TCFpc_1(\$) \tag{4-27-8}$$

$\boldsymbol{SKU_n}$

Mixed SKU Cost to Load Pallets per Container SKU_n

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times Npc_n\right) + ((pCE_n + pTC) \times (Nbpc_n \div NbpE_n)) = Cpc_n(\$) \tag{4-27-9}$$

* If $Nbpc_n \div NbpE_n$ is not a whole number, roundup to the nearest whole number

Mixed SKU Occupied Container Volume of Pallets and Boxes SKU$_n$

$$Tpbvc_n \div ucvpb = Ocvpb_n \; (Volume\%) \tag{4-27-10}$$

Mixed SKU Drayage Cost Exporter Palletized SKU$_n$

$$DCEc \times Ocvpb_n = \; DCEc_n \; (\$) \tag{4-27-11}$$

Mixed SKU Shipping Cost Palletized SKU$_n$

$$SCc \times Ocvpb_n = \; SCc_n \; (\$) \tag{4-27-12}$$

Mixed SKU Drayage Cost Importer Palletized SKU$_n$

$$DCIc \times Ocvpb_n = \; DCIc_n \; (\$) \tag{4-27-13}$$

Mixed SKU Unloading Cost Palletized SKU$_n$

$$\left((LCpc \div \textstyle\sum_{i=1}^{n} Npc_i) \; \times Npc_n\right) + ((pCI_n \times \; TpIc_n) \times PCI_n) = \; Cupc_n \; (\$) \tag{4-27-14}$$

*If additional pallets are needed for importer, then$(pCI_n \times TpIc_n)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost per Full Palletized Container SKU$_n$

$$Cpc_n + DCEc_n \; + \; SCc_n + \; DCIc_n + Cupc_n = \; TCFpc_n(\$) \tag{4-27-15}$$

4.3.1 Mixed SKU Partial Cost for Partially Filled Containers

Partial containers exist when demand cannot be met in full containers. An excess container is likely when comparing boxes to meet demand floor loaded to boxes meeting demand unitized on pallets. The cost of loading and unloading is similar to full containers, but excess boxes and excess pallets and boxes are considered. The loading cost for excess boxes is proportional to a full container. The loading cost of loading pallets is proportional to the cost of loading a full container with pallets. Equations 4-28-1 and 4-28-8 display the calculations for floor loaded boxes. The calculations to determine the cost of loading boxes unitized on pallets are shown in Equations 4-29-1 and 4-29-8. The pallet cost is considered for the number of excess pallets.

The occupied container volume for excess boxes floor loaded is determined by multiplying the number of excess boxes by the individual box volume for the specified SKU. The result is divided by the useable container volume, as shown in Equations 4-28-2 and 4-28-9. The occupied container volume for excess pallets and boxes is obtained by multiplying the number of excess pallets by the unit load volume (including pallet volume). The result is divided by the useable container volume obtained for pallets, as shown in Equations 4-29-2 and 4-29-9.

The obtained occupied container volume for either excess boxes or excess pallets and boxes is multiplied by the export drayage, shipping and import drayage costs to determine the partial costs assigned to each SKU. The calculations for floor loaded boxes are demonstrated in Equations 4-28-3 through 4-28-5 for SKU_1 and 4-28-10 through 4-28-12 for SKU_n. For boxes unitized on pallets, the calculations are demonstrated in Equations 4-29-3 through 4-29-5 for SKU_1 and in Equations 4-29-10 through 4-29-12 for SKU_n.

The unloading cost considers pallets for both loading methods. Additional pallets may be needed for the importer, even if product arrives palletized. However, phytosanitation costs are not included for the importer. For boxes floor loaded, the unloading cost calculations are shown in Equations 4-28-6 for SKU_1 and 4-28-13 for SKU_n. Equations 4-29-6 and 4-29-13 provide the unloading cost calculation for boxes unitized on pallets. The total cost for a partially charged container is determined by summing the loading cost, drayage costs, shipping cost, and unloading cost for boxes floor loaded and boxes unitized on pallets, as shown in Equations 4-28-7 and 4-28-14 for boxes floor loaded, and in Equations 4-29-7 and 4-29-14 for boxes unitized on pallets.

Table 4-28 Mixed SKU Partial Container Costs Floor Loaded Defined

Abbreviation	Definition
$LCfbc$	Labor Cost to Floor Load Boxes per Container
$Nfbc_i$	Sum of the Number of Floor Loaded Boxes per Full Container SKU $_{1\ldots n}$
$efbc_1$	Excess Floor Loaded Boxes per Container SKU $_1$
$efbc_n$	Excess Floor Loaded Boxes per Container SKU $_n$
$LCfebc_1$	Labor Cost to Floor Load Excess Boxes in Container SKU $_1$
$LCfebc_n$	Labor Cost to Floor Load Excess Boxes in Container SKU $_n$
bv_1	Box Volume SKU $_1$
bv_n	Box Volume SKU $_n$
$ucvbf$	Useable Container Volume for Boxes Floor Loaded
$DCEc$	Drayage Cost Exporter per Container
$Ocveb_1$	Occupied Container Volume of Excess Boxes SKU $_1$
$Ocveb_n$	Occupied Container Volume of Excess Boxes SKU $_n$
$DCEebc_1$	Drayage Cost Exporter for Excess Boxes per Container SKU $_1$
$DCEebc_n$	Drayage Cost Exporter for Excess Boxes per Container SKU $_n$
SCc	Shipping Cost per Container
$SCebc_1$	Shipping Cost for Excess Boxes per Container SKU $_1$
$SCebc_n$	Shipping Cost for Excess Boxes per Container SKU $_n$
$DCIc$	Drayage Cost Importer per Container
$DCIebc_1$	Drayage Cost Importer for Excess Boxes per Container SKU $_1$
$DCIebc_n$	Drayage Cost Importer for Excess Boxes per Container SKU $_n$
$LCufbc$	Labor Cost to Unload Floor Loaded Boxes from a Container
$NbpI_1$	Number of Boxes per Pallet Importer SKU $_1$
$NbpI_n$	Number of Boxes per Pallet Importer SKU $_n$
pCI_1	Pallet Cost Importer SKU $_1$
pCI_n	Pallet Cost Importer SKU $_n$
$Cuefc_1$	Costs (labor and pallets) to Unload Excess Floor Loaded Boxes per Container SKU $_1$
$Cuefc_n$	Costs (labor and pallets) to Unload Excess Floor Loaded Boxes per Container SKU $_n$
$TCefc_1$	Total (Shipping and Handling) Cost for an Excess Floor Loaded Container SKU $_1$ (
$TCefc_n$	Total (Shipping and Handling) Cost for an Excess Floor Loaded Container SKU $_n$

$\boldsymbol{SKU_1}$

Mixed SKU Loading Cost for Excess Boxes Floor Loaded SKU$_1$

$$\left(LCfbc \div \sum_{i=1}^{n} Nfbc_i\right) \times efbc_1 = LCfebc_1(\$) \tag{4-28-1}$$

Mixed SKU Occupied Container Volume Floor Loaded Boxes SKU$_1$

$$(efbc_1 \times bv_1) \div ucvbf = Ocveb_1\ (Volume\%) \tag{4-28-2}$$

Mixed SKU Drayage Cost Exporter Excess Floor Loaded Boxes SKU_1

$$DCEc \times Ocveb_1 = DCEebc_1(\$) \quad (4\text{-}28\text{-}3)$$

Mixed SKU Shipping Cost Excess Boxes Floor Loaded SKU_1

$$SCc \times Ocveb_1 = SCebc_1(\$) \quad (4\text{-}28\text{-}4)$$

Mixed SKU Drayage Cost Importer Excess Boxes Floor Loaded SKU_1

$$DCIc \times Ocveb_1 = DCIebc_1(\$) \quad (4\text{-}28\text{-}5)$$

Mixed SKU Unloading Cost Excess Boxes Floor Loaded SKU_1

$$\left((LCufbc \div \textstyle\sum_{i=1}^{n} Nfbc_i) \times efbc_1\right) + ((efbc_1 \div NbpI_1) \times PCI_1) = Cuefc_1(\$) \quad (4\text{-}28\text{-}6)$$

Mixed SKU Total Cost Excess Boxes Floor Loaded SKU_1

$$LCfebc_1 + DCEebc_1 + SCebc_1 + DCIebc_1 + Cuefc_1 = TCefc_1\ (\$) \quad (4\text{-}28\text{-}7)$$

$\boldsymbol{SKU_n}$

Mixed SKU Loading Cost for Excess Boxes Floor Loaded SKU_n

$$(LCfbc \div \textstyle\sum_{i=1}^{n} Nfbc_i) \times efbc_n = LCfebc_n(\$) \quad (4\text{-}28\text{-}8)$$

Mixed SKU Occupied Container Volume Floor Loaded Boxes SKU_n

$$(efbc_n \times bv_n) \div ucvbf = Ocveb_n\ (Volume\%) \quad (4\text{-}28\text{-}9)$$

Mixed SKU Drayage Cost Exporter Excess Boxes Floor Loaded SKU_n

$$DCEc \times Ocveb_n = DCEebc_n(\$) \quad (4\text{-}28\text{-}10)$$

Mixed SKU Shipping Cost Excess Boxes Floor Loaded SKU_n

$$SCc \times = Ocveb_n = SCebc_n(\$) \quad (4\text{-}28\text{-}11)$$

Mixed SKU Drayage Cost Importer Excess Boxes Floor Loaded SKU_n

$$DCIc \times Ocveb_n = DCIebc_n\ (\$) \quad (4\text{-}28\text{-}12)$$

Mixed SKU Unloading Cost Excess Boxes Floor Loaded SKU_n

$$\left((LCufbc \div \textstyle\sum_{i=1}^{n} Nfbc_i) \times efbc_n\right) + ((efbc_n \div NbpI_n) \times PCI_n) = Cuefc_n(\$) \quad (4\text{-}28\text{-}13)$$

Mixed SKU Total Cost Excess Boxes Floor Loaded SKU_n

$$LCfebc_n + DCEebc_n + SCebc_n + DCIebc_n + Cuefc_n = TCefc_n\ (\$) \quad (4\text{-}28\text{-}14)$$

Table 4-29 Mixed SKU Partial Container Costs Palletized Defined

Abbreviation	Definition
$LCpc$	Labor Cost to Load Palletized Boxes per Container
Npc_1	Number of Pallets per Full Container SKU $_1$
Npc_n	Number of Pallets per Full Container SKU $_n$
Npc_i	Sum of the Number of Pallets per Full Container SKU $_i$
epc_1	Excess Pallets per Container SKU$_1$
epc_n	Excess Pallets per Container SKU $_n$
pCE_1	Pallet Cost Exporter SKU$_1$
pCE_n	Pallet Cost Exporter SKU $_n$
pTC	Pallet Treatment Cost
$Nbpc_1$	Number of Boxes Palletized per Container SKU$_1$
$Nbpc_n$	Number of Boxes Palletized per Container SKU $_n$
$NbpE_1$	Number of Boxes per Pallet Exporter SKU$_1$
$NbpE_n$	Number of Boxes per Pallet Exporter SKU $_n$
$Cepc_1$	Costs (labor and pallets) to Load Excess Palletized Boxes per Container SKU$_1$
$Cepc_n$	Costs (labor and pallets) to Load Excess Palletized Boxes per Container SKU $_n$
pbv_1	Pallet and Box Volume SKU$_1$
pbv_n	Pallet and Box Volume SKU $_n$
$ucvpb$	Useable Container Volume for Pallets and Boxes
$Ocvepb_1$	Occupied Container Volume of Excess Pallets and Boxes SKU$_1$
$Ocvepb_n$	Occupied Container Volume of Excess Pallets and Boxes SKU $_n$
$DCEc$	Drayage Cost Exporter per Container
$DCEepc_1$	Drayage Cost Exporter for Excess Pallets and Boxes per Container SKU $_1$
$DCEepc_n$	Drayage Cost Exporter for Excess Pallets and Boxes per Container SKU $_n$
SCc	Shipping Cost per Container
$SCepc_1$	Shipping Cost for Excess Pallets and Boxes per Container SKU $_1$
$SCepc_n$	Shipping Cost for Excess Pallets and Boxes per Container SKU $_n$
$DCIc$	Drayage Cost Importer per Container
$DCIepc_1$	Drayage Cost Importer for Excess Pallets and Boxes per Container SKU $_1$
$DCIepc_n$	Drayage Cost Importer for Excess Pallets and Boxes per Container SKU $_n$
$LCupc$	Labor Cost to Unload Palletized Boxes from a Container
pCI_1	Pallet Cost Importer SKU$_1$
pCI_n	Pallet Cost Importer SKU $_n$
$TePIc_1$	Total Excess Pallets needed per Import Container SKU$_1$
$TePIc_n$	Total Excess Pallets needed per Import Container SKU $_n$
$Cuepc_1$	Costs (labor and pallets) to Unload Excess Palletized Boxes per Container SKU$_1$
$Cuepc_n$	Costs (labor and pallets) to Unload Excess Palletized Boxes per Container SKU $_n$
$TCepc_1$	Total (Shipping and Handling) Cost for an Excess Palletized Container SKU$_1$ (Partial)
$TCepc_n$	Total (Shipping and Handling) Cost for an Excess Palletized Container SKU $_n$ (Partial)

$\boldsymbol{SKU_1}$

Mixed SKU Loading Cost for Excess Pallets SKU$_1$

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times epc_1\right) + ((pCE_1 + pTC) \times (Nbpc_1 \div NbpE_1)) = Cepc_1(\$) \quad (4\text{-}29\text{-}1)$$

Mixed SKU Occupied Container Volume of Excess Pallets and Boxes SKU$_1$

$$(epc_1 \times pbv_1) \div ucvpb = Ocvepb_1\ (Volume\%) \quad (4\text{-}29\text{-}2)$$

Mixed SKU Drayage Cost Exporter Excess Pallets and Boxes SKU$_1$

$$DCEc \times Ocvepb_1 = DCEepc_1(\$) \quad (4\text{-}29\text{-}3)$$

Mixed SKU Shipping Cost Excess Pallets and Boxes SKU$_1$

$$SCc \times = Ocvepb_1 = SCepc_1(\$) \quad (4\text{-}29\text{-}4)$$

Mixed SKU Drayage Cost Importer Excess Pallets and Boxes SKU$_1$

$$DCIc \times Ocvepb_1 = DCIepc_1\ (\$) \quad (4\text{-}29\text{-}5)$$

Mixed SKU Unloading Cost Excess Pallets and Boxes SKU$_1$

$$\left((LCupc \div \sum_{i=1}^{n} Npc_i) \times epc_1\right) + (pCI_1 \times TePIc_1) = Cuepc_1(\$) \quad (4\text{-}29\text{-}6)$$

*If additional pallets are needed for importer, then $(pCI_1 \times TpI_1)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost Excess Pallets and Boxes Palletized SKU$_1$

$$Cepc_1 + DCEepc_1 + SCepc_1 + DCIepc_1 + Cuepc_1 = TCepc_1\ (\$) \quad (4\text{-}29\text{-}7)$$

$\boldsymbol{SKU_n}$

Mixed SKU Loading Cost for Excess Pallets SKU$_n$

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times epc_n\right) + ((pCE_n + pTC) \times (Nbpc_n \div NbpE_n)) = Cepc_n(\$) \quad (4\text{-}29\text{-}8)$$

Mixed SKU Occupied Container Volume of Excess Pallets and Boxes SKU$_n$

$$(epc_n \times pbv_n) \div ucvpf = Ocvepb_n\ (Volume\%) \quad (4\text{-}29\text{-}9)$$

Mixed SKU Drayage Cost Exporter Excess Pallets and Boxes SKU$_n$

$$DCEc \times Ocvepb_n = DCEepc_n(\$) \quad (4\text{-}29\text{-}10)$$

Mixed SKU Shipping Cost Excess Pallets and Boxes SKU$_n$

$$SCc \times Ocvepb_n = SCepc_n(\$) \quad (4\text{-}29\text{-}11)$$

Mixed SKU Drayage Cost Importer Excess Pallets and Boxes SKU$_n$

$$DCIc \times Ocvepb_n = DCIepc_n\ (\$) \quad (4\text{-}29\text{-}12)$$

Mixed SKU Unloading Cost for Excess Pallets and Boxes SKU$_n$

$$\left((LCupc \div \textstyle\sum_{i=1}^{n} Npc_i) \times epc_n\right) + (pCI_n \times TePIc_n) = Cuepc_n(\$) \quad (4\text{-}29\text{-}13)$$

*If additional pallets are needed for importer, then $(pCI_1 \times TpI_1)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost Excess Pallets and Boxes Palletized SKU$_n$

$$Cepc_n + DCEepc_n + SCepc_n + DCIepc_n + Cuepc_n = TCepc_n\ (\$) \quad (4\text{-}29\text{-}14)$$

4.3.2 Mixed SKU Cost Meeting Daily Demand Full Charged Containers

For mixed SKU shipments that cannot meet demand in full container shipments, excess container space exists. This scenario results in full transport/shipping costs and partial handling costs. Only the last container of the shipment to meet demand should be considered for this option, and only if excess space and costs cannot be absorbed by additional products. Mixed SKU containers consider a cost of excess space given the number of varying SKU's and amount of space used.

For fully charged excess containers, loading and unloading are calculated the same as partially charged excess containers for boxes floor loaded and boxes unitized on pallets. The difference is found in the export drayage, shipping, and import drayage costs. The shipping and drayage costs are full, and are based from the total volume of excess boxes or total volume of unit loads per container. Equation 4-30-2 displays the calculation for boxes floor loaded. Equation 4-31-2 provides the calculation for boxes unitized on pallets. Dividing the shipping and drayage costs by the total volume of excess boxes or boxes and pallets, and multiplying the result by the volume of the specified SKU, a cost is determined for shipping and drayage for each loading method. The calculations for floor loaded boxes are provided in Equations 4-30-3 through 4-30-5 for SKU_1, and in Equations 4-30-9 through 4-30-11 for SKU_n. The calculations to determine the shipping and drayage cost per SKU for boxes unitized on pallets is provided in Equations 4-31-3 through 4-31-5 for SKU_1, and Equations 4-31-9 through 4-31-11 for SKU_n.

The total cost for an excess container charged in full is determined by summing the loading cost, export drayage, shipping and import drayage costs for boxes floor loaded and boxes unitized on pallets.

Table 4-30 Mixed SKU Full Charged Partial Containers Floor Loaded Defined

Abbreviation	Definition
$LCfbc$	Labor Cost to Floor Load Boxes per Container
$Nfbc_1$	Number of Floor Loaded Boxes per Full Container SKU$_1$
$Nfbc_n$	Number of Floor Loaded Boxes per Full Container SKU $_n$
$Nfbc_i$	Sum of the Number of Floor Loaded Boxes per Full Container SKU $_{1\ldots n}$
$efbc_1$	Excess Floor Loaded Boxes per Container SKU$_1$
$efbc_n$	Excess Floor Loaded Boxes per Container SKU $_n$
$efbvc_i$	Sum of Excess Floor Loaded Boxes per Container SKU $_{1\ldots n}$
bv_1	Box Volume SKU$_1$
bv_n	Box Volume SKU $_n$
$LCfebc_1$	Labor Cost to Floor Load Excess Boxes in Container SKU$_1$
$LCfebc_n$	Labor Cost to Floor Load Excess Boxes in Container SKU $_n$
$DCEc$	Drayage Cost Exporter per Container
$DCEebc_1$	Drayage Cost Exporter for Excess Boxes per Container SKU $_1$
$DCEebc_n$	Drayage Cost Exporter for Excess Boxes per Container SKU $_n$
SCc	Shipping Cost per Container
$SCebc_1$	Shipping Cost for Excess Boxes per Container SKU $_1$
$SCebc_n$	Shipping Cost for Excess Boxes per Container SKU $_n$
$DCIc$	Drayage Cost Importer per Container
$DCIebc_1$	Drayage Cost Importer for Excess Boxes per Container SKU $_1$
$DCIebc_n$	Drayage Cost Importer for Excess Boxes per Container SKU $_n$
$LCufc$	Labor Cost to Unload Floor Loaded Boxes from a Container
$NbpI_1$	Number of Boxes per Pallet Importer SKU$_1$
$NbpI_n$	Number of Boxes per Pallet Importer SKU $_n$
pCI_1	Pallet Cost Importer SKU$_1$
pCI_n	Pallet Cost Importer SKU $_n$
$Cuefc_1$	Costs (labor and pallets) to Unload Excess Floor Loaded Boxes per Container SKU$_1$
$Cuefc_n$	Costs (labor and pallets) to Unload Excess Floor Loaded Boxes per Container SKU $_n$
$TCefc_1{}^*$	Total (Shipping and Handling) Costs for an Excess Floor loaded Container (Full) SKU$_1$
$TCefc_n{}^*$	Total (Shipping and Handling) Costs for an Excess Floor Loaded Container (Full)SKU$_n$

$\boldsymbol{SKU_1}$

Mixed SKU Loading Cost for Floor Loaded Boxes SKU$_1$

$$(LCfbc \div \sum_{i=1}^{n} Nfbc_i) \times efbc_1 = LCfebc_1(\$) \qquad (4\text{-}30\text{-}1)$$

Mixed SKU Total Volume of Excess Boxes Floor Loaded SKU$_{1\ldots n}$

$$(efbc_1 \times bv_1) + (efbc_n \times bv_n) = \sum_{i=1}^{n} efbvc_i \,(Volume) \qquad (4\text{-}30\text{-}2)$$

Mixed SKU Drayage Cost Exporter Excess Floor Loaded Boxes SKU$_1$

$$(DCEc \div \sum_{i=1}^{n} efbvc_i) \times efbvc_1 = DCEebc_1(\$) \qquad (4\text{-}30\text{-}3)$$

Mixed SKU Shipping Cost Excess Floor Loaded Boxes SKU$_1$

$$(SC \div \sum_{i=1}^{n} efbvc_i) \times efbvc_1 = SCebc_1(\$) \qquad (4\text{-}30\text{-}4)$$

Mixed SKU Drayage Cost Importer Excess Boxes Floor Loaded SKU$_1$

$$(DCIc \div \sum_{i=1}^{n} efbvc_i) \times efbvc_1 = DCIebc_1(\$) \qquad (4\text{-}30\text{-}5)$$

Mixed SKU Unloading Cost for Floor Loaded Boxes SKU$_1$

$$\left((LCufc \div \sum_{i=1}^{n} Nfbc_i) \times efbc_1\right) + ((Nfbc_1 \div NbpI_1) \times PCI_1) = Cuefc_1(\$) \qquad (4\text{-}30\text{-}6)$$

Mixed SKU Total Cost per Excess Container Floor Loaded Charged Full SKU$_1$

$$LCfebc_1 + DCEebc_1 + SCebc_1 + DCIebc_1 + Cuefc_1 = TCefc_1{}^{*} \ (\$) \qquad (4\text{-}30\text{-}7)$$

$\boldsymbol{SKU_n}$

Loading Cost for Floor Loaded Boxes SKU$_n$

$$(LCfbc \div \sum_{i=1}^{n} Nfbc_i) \times efbc_n = LCfebc_n(\$) \qquad (4\text{-}30\text{-}8)$$

Mixed SKU Drayage Cost Exporter Excess Floor Loaded Boxes SKU$_n$

$$(DCEc \div \sum_{i=1}^{n} efbvc_i) \times efbvc_n = DCEebc_n(\$) \qquad (4\text{-}30\text{-}9)$$

Mixed SKU Shipping Cost Excess Floor Loaded Boxes SKU$_n$

$$(SCc \div \sum_{i=1}^{n} efbvc_i) \times efbvc_n = SCebc_n(\$) \qquad (4\text{-}30\text{-}10)$$

Mixed SKU Drayage Cost Importer Excess Boxes Floor Loaded SKU$_n$

$$(DCIc \div \sum_{i=1}^{n} efbvc_i) \times efbvc_n = DCIebc_n \ (\$) \qquad (4\text{-}30\text{-}11)$$

Mixed SKU Unloading Cost for Floor Loaded Boxes SKU$_n$

$$\left((LCufbc \div \sum_{i=1}^{n} Nfbc_i) \times efbc_n\right) + ((Nfbc_n \div NbpI_n) \times PCI_n) = Cuefc_n(\$) \quad (4\text{-}30\text{-}12)$$

Mixed SKU Total Cost per Excess Container Floor Loaded Charged Full SKU$_n$

$$LCfebc_n + DCEebc_n + SCebc_n + DCIebc_n + Cuefc_n = TCefc_n^* \text{ (\$)} \qquad (4\text{-}30\text{-}13)$$

Table 4-31 Mixed SKU Full Charged Partial Containers Palletized Defined

Abbreviation	Definition
$LCpc$	Labor Cost to Load Palletized Boxes per Container
Npc_i	Number of Pallets per Full Container SKU$_{1...n}$
epc_1	Excess Pallets per Container SKU$_1$
epc_n	Excess Pallets per Container SKU $_n$
pbv_1	Pallet and Box Volume SKU$_1$
pbv_n	Pallet and Box Volume SKU $_n$
$epbvc_i$	Sum of the Excess Pallet and Box Volume per Container SKU$_{1...n}$
pCE_1	Pallet Cost Exporter SKU$_1$
pCE_n	Pallet Cost Exporter SKU $_n$
pTC	Pallet Treatment Cost
$Nbpc_1$	Number of Boxes Palletized per Container SKU$_1$
$Nbpc_n$	Number of Boxes Palletized per Container SKU $_n$
$NbpE_1$	Number of Boxes per Pallet Exporter SKU$_1$
$NbpE_n$	Number of Boxes per Pallet Exporter SKU $_n$
$Cepc_1$	Costs (labor and pallets) to Load Excess Palletized Boxes per Container SKU$_1$
$Cepc_n$	Costs (labor and pallets) to Load Excess Palletized Boxes per Container SKU $_n$
$DCEc$	Drayage Cost Exporter per Container
$DCEepc_1$	Drayage Cost Exporter for Excess Pallets and Boxes per Container SKU$_1$
$DCEepc_n$	Drayage Cost Exporter for Excess Pallets and Boxes per Container SKU $_n$
SCc	Shipping Cost per Container
$SCepc_1$	Shipping Cost for Excess Pallets and Boxes per Container SKU$_1$
$SCepc_n$	Shipping Cost for Excess Pallets and Boxes per Container SKU $_n$
$DCIc$	Drayage Cost Importer per Container
$DCIepc_1$	Drayage Cost Importer for Excess Pallets and Boxes per Container SKU$_1$
$DCIepc_n$	Drayage Cost Importer for Excess Pallets and Boxes per Container SKU $_n$
$LCupc$	Labor Cost to Unload Palletized Boxes from a Container
pCI_1	Pallet Cost Importer SKU$_1$
pCI_n	Pallet Cost Importer SKU $_n$
$TePIc_1$	Total Excess Pallets needed per Import Container SKU$_1$
$TePIc_n$	Total Excess Pallets needed per Import Container SKU $_n$
$Cuepc_1$	Costs (labor and pallets) to Unload Excess Palletized Boxes per Container SKU$_1$
$Cuepc_n$	Costs (labor and pallets) to Unload Excess Palletized Boxes per Container SKU $_n$
$TCepc_1^*$	Total (Shipping and Handling) Costs for an Excess Palletized Container (Full) SKU$_1$
$TCepc_n^*$	Total (Shipping and Handling) Costs for an Excess Palletized Container (Full) SKU $_n$

$\boldsymbol{SKU_1}$

Mixed SKU Loading Cost for Palletized Boxes SKU_1

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times epc_1\right) + ((pCE_1 + pTC) \times (Nbpc_1 \div NbpE_1)) = Cepc_1(\$) \quad (4\text{-}31\text{-}1)$$

Mixed SKU Total Volume of Excess Pallets and Boxes $SKU_{1\ldots n}$

$$(epc_1 \times pbv_1) + (epc_n \times pbv_n) = \sum_{i=1}^{n} epbvc_i\ (Volume) \quad (4\text{-}31\text{-}2)$$

Mixed SKU Drayage Cost Exporter Excess Palletized Boxes SKU_1

$$(DCEc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_1 = DCEepc_1(\$) \quad (4\text{-}31\text{-}3)$$

Mixed SKU Shipping Cost Excess Palletized Boxes SKU_1

$$(SCc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_1 = SCepc_1(\$) \quad (4\text{-}31\text{-}4)$$

Mixed SKU Drayage Cost Importer Excess Boxes Palletized SKU_1

$$(DCIc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_1 = DCIepc_1\ (\$) \quad (4\text{-}31\text{-}5)$$

Mixed SKU Unloading Cost for Palletized Boxes SKU_1

$$\left((LCupc \div \sum_{i=1}^{n} Npc_i) \times epc_1\right) + (pCI_1 \times TePIc_1) = Cuepc_1(\$) \quad (4\text{-}31\text{-}6)$$

*If additional pallets are needed for importer, then $(pCI_1 \times TpI_1)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost per Excess Container Palletized Charged Full SKU_1

$$Cepc_1 + DCEepc_1 + SCepc_1 + DCIepc_1 + Cuepc_1 = TCepc_1{}^{*}\ (\$) \quad (4\text{-}31\text{-}7)$$

$\boldsymbol{SKU_n}$

Mixed SKU Loading Cost for Palletized Boxes SKU_n

$$\left((LCpc \div \sum_{i=1}^{n} Npc_i) \times epc_n\right) + ((pCE_n + pTC) \times (Nbpc_n \div NbpE_n)) = Cepc_n(\$) \quad (4\text{-}31\text{-}8)$$

Mixed SKU Drayage Cost Exporter Excess Palletized Boxes SKU_n

$$(DCEc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_n = DCEepc_n(\$) \quad (4\text{-}31\text{-}9)$$

Mixed SKU Shipping Cost Excess Palletized Boxes SKU_n

$$(SCc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_n = SCepc_n(\$) \quad (4\text{-}31\text{-}10)$$

Mixed SKU Drayage Cost Importer Excess Boxes Palletized SKU$_n$

$$(DCIc \div \sum_{i=1}^{n} epbvc_i) \times epbvc_n = DCIepc_n \text{ (\$)} \quad (4\text{-}31\text{-}11)$$

Mixed SKU Unloading Cost for Palletized Boxes SKU$_n$

$$\left((LCupc \div \sum_{i=1}^{n} Npc_i) \times epc_n\right) + (pCI_n \times TePIc_n) = Cuepc_n (\$) \quad (4\text{-}31\text{-}12)$$

*If additional pallets are needed for importer, then $(pCI_1 \times TpI_1)$; if no additional pallets are needed, substitute (0, 0)

Mixed SKU Total Cost per Excess Container Palletized Charged Full SKU$_n$

$$Cepc_n + DCEepc_n + SCepc_n + DCIepc_n + Cuepc_n = TCepc_n{}^{*} \text{ (\$)} \quad (4\text{-}31\text{-}13)$$

4.3.1 Mixed SKU Cost Meeting Daily Demand

Once total shipping and handling costs per container have been calculated per SKU, and the container demand per SKU is known, daily costs for floor loaded and palletized boxes can be determined per SKU. From the calculations, the total cost for full containers and full containers with the addition of an excess container (charged either partial or full) are obtained. The calculations are the same as single SKU containers, but each SKU is determined for each loading method as shown in Equations 4-32-1 through 4-32-6 for floor loaded boxes and in Equations 4-33-1 through 3-33-6.

Table 4-32 Mixed SKU Cost Meeting Demand Floor Loaded Defined

Abbreviation	Definition
$TCFfc_1$	Total (Shipping and Handling) Costs per Full Floor Loaded Container SKU$_1$
$TCFfc_n$	Total (Shipping and Handling) Costs per Full Floor Loaded Container SKU $_n$
$NFcfd_1$	Number of Full Containers Floor Loaded per Day SKU$_1$
$NFcfd_n$	Number of Full Containers Floor Loaded per Day SKU $_n$
$TCFcfd_1$	Total Cost for Full Containers Floor Loaded per Day SKU$_1$
$TCFcfd_n$	Total Cost for Full Containers Floor Loaded per Day SKU $_n$
$TCefc_1$	Total (Shipping and Handling) Cost for an Excess Floor Loaded Container SKU$_1$ (Partial)
$TCefc_n$	Total (Shipping and Handling) Cost for an Excess Floor Loaded Container SKU $_n$ (Partial)
$TCfcd_1$	Total Cost for Floor Loaded Container(s) per day SKU$_1$ (including partial charged container)
$TCfcd_n$	Total Cost for Floor Loaded Container(s) per day SKU $_n$ (including partial charged container)
$TCefc_1{}^*$	Total (Shipping and Handling) Costs for an Excess Floor loaded Container (Full) SKU$_1$
$TCefc_n{}^*$	Total (Shipping and Handling) Costs for an Excess Floor Loaded Container (Full) SKU$_n$
$TCfcd_1{}^*$	Total Cost for Floor Loaded Container(s) per day SKU$_1$ (including full charged excess container)
$TCfcd_n{}^*$	Total Cost for Floor Loaded Container(s) per day SKU$_n$ (including full charged excess container)

$\boldsymbol{SKU_1}$

Mixed SKU Total Cost per Full Containers Floor Loaded SKU$_1$

$$TCFfc_1 \times NFcfd_1 = TCFcfd_1 \text{ (\$)} \tag{4-32-1}$$

Mixed SKU Total Cost per Floor Loaded Containers per Day Partial Charged SKU$_1$

$$TCFcfd_1 + TCefc_1 = TCfcd_1 \text{ (\$)} \tag{4-32-2}$$

Mixed SKU Total Cost per Floor Loaded Containers per Day Full Charged SKU$_1$

$$TCFcfd_1 + TCefc_1{}^* = TCfcd_1{}^* \text{ (\$)} \tag{4-32-3}$$

$\boldsymbol{SKU_n}$

Mixed SKU Total Cost per Full Containers Floor Loaded SKU$_n$

$$TCFfc_n \times NFcfd_n = TCFcfd_n \text{(\$)} \tag{4-32-4}$$

Mixed SKU Total Cost per Floor Loaded Containers per Day Partial Charged SKU$_n$

$$TCFcfd_n + TCefc_n = TCfcd_n\ (\$) \qquad (4\text{-}32\text{-}5)$$

Mixed SKU Total Cost per Floor Loaded Containers per Day Full Charged SKU$_n$

$$TCFcfd_n + TCefc_n{}^* = TCfcd_n{}^*(\$) \qquad (4\text{-}32\text{-}6)$$

Table 4-33 Mixed SKU Cost Meeting Demand Palletized Defined

Abbreviation	Definition
$TCFpc_1$	Total (Shipping and Handling) Costs per Full Palletized Container SKU$_1$
$TCFpc_n$	Total (Shipping and Handling) Costs per Full Palletized Container SKU $_n$
$NFcpd_1$	Number of Full Containers Palletized per Day SKU$_1$
$NFcpd_n$	Number of Full Containers Palletized per Day SKU $_n$
$TCFcpd_1$	Total Cost for Full Containers Palletized per Day SKU$_1$
$TCFcpd_n$	Total Cost for Full Containers Palletized per Day SKU $_n$
$TCepc_1$	Total (Shipping and Handling) Cost for an Excess Palletized Container SKU$_1$ (Partial)
$TCepc_n$	Total (Shipping and Handling) Cost for an Excess Palletized Container SKU $_n$ (Partial)
$TCpcd_1$	Total Cost for Palletized Container(s) per day SKU$_1$ (including partial charged container)
$TCpcd_n$	Total Cost for Palletized Container(s) per day SKU $_n$ (including partial charged container)
$TCepc_1{}^*$	Total (Shipping and Handling) Costs for an Excess Palletized Container (Full) SKU$_1$
$TCepc_n{}^*$	Total (Shipping and Handling) Costs for an Excess Palletized Container (Full) SKU $_n$
$TCpcd_1{}^*$	Total Cost for Palletized Container(s) per day SKU$_1$ (including full charged excess container)
$TCpcd_n{}^*$	Total Cost for Palletized Container(s) per day SKU$_n$ (including full charged excess container)

SKU_1

Mixed SKU Total Cost per Full Containers Palletized SKU$_1$

$$TCFpc_1 \times NFcpd_1 = TCFcpd_1(\$) \qquad (4\text{-}33\text{-}1)$$

Mixed SKU Total Cost per Palletized Containers per Day Partial Charged SKU$_1$

$$TCFcpd_1 + TCepc_1 = TCpcd_1\ (\$) \qquad (4\text{-}33\text{-}2)$$

Mixed SKU Total Cost per Floor Loaded Containers per Day Full Charged SKU$_1$

$$TCFcpd_1 + TCepc_1{}^* = TCpcd_1{}^*(\$) \qquad (4\text{-}33\text{-}3)$$

SKU_n

Mixed SKU Total Cost per Full Containers Palletized SKU_n

$$TCpc_n \times NFcpd_n = TCFcpd_n(\$) \tag{4-33-4}$$

Mixed SKU Total Cost per Palletized Containers per Day Partial Charged SKU_n

$$TCFcpd_n + TCepc_n = TCpcd_n\ (\$) \tag{4-33-5}$$

Mixed SKU Total Cost per Palletized Containers per Day Full Charged SKU_n

$$TCFcpd_n + TCepc_n{}^* = TCpcd_n{}^*(\$) \tag{4-33-6}$$

4.3.2 Mixed SKU Net Value Floor Loaded Meeting Daily Demand

The following equations are used to determine the daily net value per SKU for floor loaded and palletized containers. The equations are the same as single SKU, but each SKU is considered for the two loading methods. The total cost meeting daily demand is subtracted from the product value per day. A partial charge for excess containers (if applicable) is considered in Equations 4-34-1 and 4-34-2 for floor loaded boxes, and in Equations 4-35-1 and 4-35-2 for boxes unitized on pallets. A full charge for excess containers (if applicable) is shown in Equations 4-34-3 and 4-34-4 for boxes floor loaded, and in Equations 4-35-3 and 4-35-4 for boxes unitized on pallets.

Table 4-34 Mixed SKU Net Value Floor Loaded Meeting Demand Defined

Abbreviation	Definition
$PVdf_1$	Product Value per Day Floor Loaded SKU_1
$PVdf_n$	Product Value per Day Floor Loaded SKU_n
$TCfcd_1$	Total Cost for Floor Loaded Container(s) per day SKU_1 (including partial charged container)
$TCfcd_n$	Total Cost for Floor Loaded Container(s) per day SKU_n (including partial charged container)
nVf_1	Net Value Floor Loaded SKU_1
nVf_n	Net Value Floor Loaded SKU_n
$TCfcd_1{}^*$	Total Cost for Floor Loaded Container(s) per day SKU_1 (including full charged excess container)
$TCfcd_n{}^*$	Total Cost for Floor Loaded Container(s) per day SKU_n (including full charged excess container)

$\boldsymbol{SKU_1}$

Mixed SKU Net Value Floor Loaded Partial Charge SKU$_1$

$$PVdf_1 - TCfcd_1 = nVf_1 \text{ (\$)} \quad (4\text{-}34\text{-}1)$$

$\boldsymbol{SKU_n}$

Mixed SKU Net Value Floor Loaded Partial Charge SKU$_n$

$$PVdf_n - TCfcd_n = nVf_n \text{ (\$)} \quad (4\text{-}34\text{-}2)$$

If excess space and costs cannot be absorbed by other products, then:

$\boldsymbol{SKU_1}$

Mixed SKU Net Value Floor Loaded Charged in Full SKU$_1$

$$PVdf_1 - TCfcd_1{}^* = nVf_1 \text{ (\$)} \quad (4\text{-}34\text{-}3)$$

$\boldsymbol{SKU_n}$

Mixed SKU Net Value Floor Loaded Charged in Full SKU$_n$

$$PVdf_n - TCfcd_n{}^* = nVf_n \text{(\$)} \quad (4\text{-}34\text{-}4)$$

Table 4-35 Mixed SKU Net Value Palletized Meeting Demand Defined

Abbreviation	Definition
$PVdp_1$	Product Value per Day Palletized SKU$_1$
$PVdp_n$	Product Value per Day Palletized SKU $_n$
$TCpcd_1$	Total Cost for Palletized Container(s) per day SKU$_1$ (including partial charged container)
$TCpcd_n$	Total Cost for Palletized Container(s) per day SKU $_n$ (including partial charged container)
nVp_1	Net Value Palletized SKU$_1$
nVp_n	Net Value Palletized SKU $_n$
$TCpcd_1{}^*$	Total Cost for Palletized Container(s) per day SKU$_1$ (including full charged excess container)
$TCpcd_n{}^*$	Total Cost for Palletized Container(s) per day SKU$_n$ (including full charged excess container)

$\boldsymbol{SKU_1}$

Mixed SKU Net Value Palletized Partial Charge SKU$_1$

$$PVdp_1 - TCpcd_1 = nVp_1 \text{(\$)} \quad (4\text{-}35\text{-}1)$$

SKU_n

Mixed SKU Net Value Palletized Partial Charge SKU_n

$$PVdp_n - TCpcd_n = nVp_n(\$) \qquad (4\text{-}35\text{-}2)$$

If excess space and costs cannot be absorbed by other products, then:

SKU_1

Mixed SKU Net Value Palletized Charged in Full SKU_1

$$PVdp_1 - TCpcd_1^{*} = nVp_1(\$) \qquad (4\text{-}35\text{-}3)$$

SKU_n

Mixed SKU Net Value Palletized Charged in Full SKU_n

$$PVdp_n - TCpcd_n^{*} = nVp_n(\$) \qquad (4\text{-}35\text{-}4)$$

4.3.3 Mixed SKU Net Value Delta Meeting Daily Demand

A positive answer (Bfp_1 or Bfp_n) results that a cost savings benefit exists for floor loading per SKU, and not for palletizing. If the answer is negative, a cost savings benefit exists for palletizing per SKU and not floor loading. The calculations are made for each SKU, as shown in Equations 4-36-1 and 4-36-2.

Table 4-36 Mixed SKU Net Value Delta Meeting Demand Defined

Abbreviation	Definition
nVf_1	Net Value Floor Loaded SKU_1
nVf_n	Net Value Floor Loaded SKU_n
nVp_1	Net Value Palletized SKU_1
nVp_n	Net Value Palletized SKU_n
Bfp_1	Benefit of Floor Loading or Palletizing SKU_1
Bfp_n	Benefit of Floor Loading or Palletizing SKU_n

SKU_1

Mixed SKU Cost Savings Benefit of Floor Loading or Palletizing SKU_1

$$nVf_1 - nVp_1 = Bfp_1(\$) \qquad (4\text{-}36\text{-}1)$$

$\boldsymbol{SKU_n}$

Mixed SKU Cost Savings Benefit of Floor Loading or Palletizing SKU_n

$$nVf_n - nVp_n = Bfp_n(\$) \tag{4-36-2}$$

4.3.4 Mixed SKU Dock Door Capacity Meeting Daily Demand

Assuming containers arrive all at one time, the calculation to determine the number of receiving dock doors that are needed can be made. If enough doors are available, then the number of containers to be received can be equal to the doors needed. For certain facilities, the number of doors is limited. This results in a container to be moved from a dock door, so another can be unloaded. The number of receiving doors needed to meet demand is determined for both loading methods by adding the container unload time to the time needed to move a container (if applicable). The result is multiplied by either the occupied container volume for boxes meeting demand, or the occupied container volume for pallets and boxes meeting demand (obtained from Equation 4-22-9 for boxes floor loaded and Equation 4-23-11 for boxes unitized). This result is divided by the available hours per receiving door, as shown in Equation 4-37-1 for boxes floor loaded and in Equation 4-38-1 for boxes unitized on pallets.

For fast moving boxed products, the goal may be to get as many boxes in during work hours. A determination for this instance is also made for both floor loaded and palletized boxes, as shown in Equations 4-37-2 and 4-38-2, respectively.

Table 4-37 Mixed SKU Dock Door Capacity Floor Loaded Meeting Demand Defined

Abbreviation	Definition
$utfc$	Unloading Time for a Floor Loaded Container
tMc	Time to Move Containers
$Ocvbd_i$	Sum of the Occupied Container Volume of Boxes per day SKU$_i$
AHR	Available Hours per Receiving Door
$NRdf$	Number of Receiving Doors Needed to Meet Daily Container Demand Floor Loaded
$mcdf$	Maximum Containers per Day per Door Floor Loaded

Mixed SKU Receiving Dock Doors Needed to Meet Demand Floor Loaded

$$\left(utfc + (tMc\ \ if\ applicable)\right) \times \left(\textstyle\sum_{i=1}^{n} Ocvbd_i\right) \div AHR = NRdf\ (Doors) \tag{4-37-1}$$

For facilities that aren't concerned with meeting demand, but rather to get as many boxed products in as possible, the calculation can be altered to accommodate this scenario.

Mixed SKU Maximum Number of Containers per Door Floor Loaded

$$(AHR\ \div (utfc\ + tMc)) = mcdf\ (Containers/Door) \tag{4-37-2}$$

Table 4-38 Mixed SKU Dock Door Capacity Palletized Meeting Demand Defined

Abbreviation	Definition
$utpc$	Unloading Time for a Palletized Container
$Ocvpbd_i$	Sum of the Occupied Container Volume of Pallets and Boxes per day SKU$_i$
tMc	Time to Move Containers
AHR	Available Hours per Receiving Dock Door
$NRdp$	Number of Receiving Doors Needed to Meet Daily Container Demand Palletized

Mixed SKU Receiving Dock Doors Needed to Meet Demand Palletized

$$\left(utpc + (tMc\ \ if\ applicable)\right) \times \left(\textstyle\sum_{i=1}^{n} Ocvpbd_i\right) \div AHR = NRdp\ (Doors) \tag{4-38-1}$$

For facilities that aren't concerned with meeting demand, but rather to get as many boxed products in as possible, the calculation can be altered to accommodate this scenario.

Mixed SKU Maximum Number of Containers per Door Palletized

$$(AHR\ \div (utpc\ + tMc)) = mcdf\ (Containers/Door) \tag{4-38-2}$$

CHAPTER 5. MODEL APPLICATION

5.1 Model Demonstration

The model was applied to select scenarios obtained from questionnaires to evaluate efficiency (cost and time). The associated costs of exporting and importing boxed products in containers are variable throughout the supply chain. The cost of loading and unloading containers is influenced by the type of labor utilized. Additionally, cost is influenced by whether or not a customer charge to perform the loading/unloading service is applied. To demonstrate the impact of labor cost on the decision to floor load boxes or unitize boxes on pallets in containers, minimum, average, and maximum labor costs for lumper, manual hourly labor, and hourly fork lift operators were applied to the following scenarios, considering the customer charge.

- Equal box count, single SKU container: The number of boxes per container floor loaded and the number of boxes unitized on pallets are equal (2,880 boxes for each loading method).
- Minimal variation in box count, single SKU container: Floor loading allows six more boxes per container than if unitized on pallets (90 boxes floor loaded compared to 84 boxes unitized on pallets).
- Medium variation in box count, single SKU container: Floor loading allows 60 more boxes per container than if unitized on pallets (1500 boxes floor loaded compared to 1440 boxes unitized on pallets).
- Large variation in box count, single SKU container: Floor loading allows 948 more boxes per container than if unitized on pallets (2460 boxes floor loaded compared to 1512 boxes unitized on pallets).

- Mixed SKU container: Three various SKUs with various demand are demonstrated. For mixed SKU containers, specific information regarding box dimensions and quantity of each SKU per container was not obtained from the questionnaires. Respondents provided a total box count per container and responded “various” to the question regarding dimensions. Arbitrary box dimensions were used to demonstrate mixed SKU containers. Floor loading allows 204 more boxes than if unitized on pallets for SKU 1 (540 boxes floor loaded compared to 336 unitized on pallets), 228 more boxes for SKU 2 (612 boxes floor loaded compared to 384 boxes unitized on pallets), and 570 more boxes for SKU 3 (1210 boxes floor loaded compared to 640 boxes unitized) per container.

To demonstrate the impact of time on the decision, container unloading times for lumper, manual hourly labor, and forklift operators were used to determine the following:

- Dock doors needed to meet demand (using container demand of one, six, and 35 obtained from data collection)
- Maximum containers per door

5.2 Assumptions

5.2.1 Labor Cost Assumptions

Data was not collected from overseas exporters. To demonstrate the model, labor cost and customer charge assumptions were made. The assumptions follow:

- Equal Cost Export Labor, Charge to Customer

For this case, the model assumes a low labor cost to load boxed products either floor loaded or palletized. The lowest cost found through questionnaires to unload a container was $4.54 (using a forklift). For equal cost export labor, the model assumes $4.54 labor cost to load boxes in a container either floor loaded or palletized (no profit is made by exporter to load boxes). The charge to a customer includes a profit to the warehouse/distribution center for unloading boxes (use labor cost obtained from questionnaires).

- Equal Cost Export Labor, No Charge to Customer

For this case, the model assumes low labor cost ($4.54) to load boxed products floor loaded or palletized. No profit is included in the cost to load or unload boxes (use labor cost obtained from questionnaires).

- Variable Export Labor Cost, Charge to Customer

This case assumes a profit is charged by the exporter (loading boxes) and the importer (unloading boxes). It is assumed that the cost to load floor loaded boxes equals the cost to unload floor loaded boxes and the cost to load palletized boxes equals the cost to unload palletized boxes (use labor cost obtained from questionnaires).

- Variable Export Labor Cost, No Charge to Customer

For this case, the model assumes no profit is charged by the exporter and importer to load/unload boxes. It is assumed that the cost to load floor loaded boxes equals cost to unload floor loaded boxes and the cost to load palletized boxes equals cost to unload palletized boxes (use labor cost obtained from questionnaires).

5.2.2 Additional Assumptions

- Pallets were assumed to be constructed of wood, but any material is acceptable.
- Export Pallet price = $10.00 ($8.00 pallet price + $2 phytosanitation cost) per pallet (regardless of application)
- Import Pallet price = $8.00 per pallet (regardless of application)

- Pallets were assumed to be at 12% moisture content and weigh 30 pounds each. (regardless of application)
- Pallets were assumed to be equal quality as pallets used in the U.S.
- The drayage cost was assumed at $240.00 per container for both export and import drayage.
- The shipping cost was assumed to be $3,000 (lump sum rate) per container.
- Partial containers are charged only for space used for shipping and drayage. Partial containers are charged partial labor rates. If a benefit does not exist charging for a partial container, a benefit will not exist charging for a full container. The model has the capability to charge full shipping and drayage. A select example is demonstrated.
- Floor loaded product is palletized at distribution centers.
- Daily demand must be met, not exceeded. The model has the capability to demonstrate an unrestricted demand. A select example is demonstrated in receiving dock doors.
- For the demonstrated scenarios, container weights are not a factor. For boxes used in the model imported floor loaded, the weights of boxes palletized do not exceed actual floor loaded weights, or are low weight items and do not portray a risk of weight concerns. For products that are imported palletized, the weights floor loaded do not exceed actual palletized weights.
- The model assumes demand can be met in one floor loaded container (commonly requiring more containers when contents are unitized on pallets); however, one example is provided for six containers floor loaded.
- The model assumes floor loaded boxes are palletized to the same pallet configuration as palletized boxes.

- It is assumed that warehouse receiving dock doors have a maximum of eight available hours (workday).
- Container dimensions of 39’5 3/8” (Length) x 7’8 1/2” (Width) x 7’10” (Height) were used for all 40’ container examples. Dimensions of 19’ 4” (Length) x 7’8 1/2” (Width) x 7’ 9 7/8” (Height) were used for 20’ containers.

* Even though assumptions were made to demonstrate the model, inputs are not limited to the assumptions, and can be changed to accommodate the user.

5.3 Equal Box Count

The selected boxed product (energy drink) is imported on 48” x 40” pallets (144 boxes per pallet, 2,880 boxes per container). Box dimensions of 12.5" (Length) x 8.25" (Width) x 5.25" (Height) were put into TOPS. Using the provided box size, pallet size, and boxes per pallet from a questionnaire respondent, Figure 5-1 was created. Each box is valued at $17.28 and weighs 15 pounds.

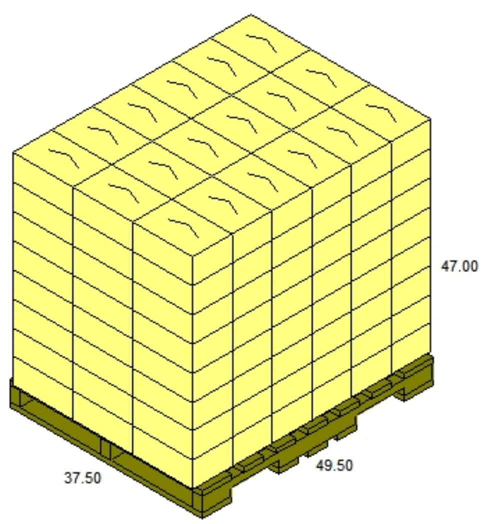

Figure 5-1 TOPS Model Equal Box Count Palletized (144)

Figure 5-2 illustrates the unit loads in a container. Table 5-1 displays weight, value, boxes per container, cube efficiency for the container, and the box to pallet efficiency. Pallet weight constitutes 600 pounds in the container.

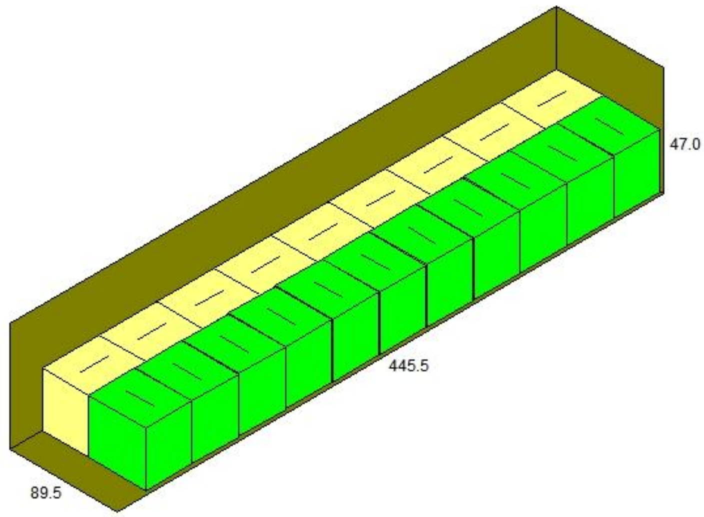

Figure 5-2 TOPS Model Equal Box Count Unit Loads 40' Container (2880 Boxes)

Table 5-1 Equal Box Count Palletized

Energy Drink 48 x 40 Palletized per 40' Container	
Total product/packaging/pallet weight	43,800
Container Value	$49,766.40
Boxes per Container	2880
Cube Efficiency	47.1%
Efficiency- pallet to package	96.6%

Since product arrives palletized, it is known that the number of boxes floor loaded can equal the number of boxes palletized. This results in an equal number of containers needed for floor loaded and palletized boxes. Removing the pallets in TOPS provides 2,880 boxes floor loaded in a container, as shown in Figure 5-3. Table 5-2 displays container weight, value, boxes per container, and cube efficiency for the floor loaded container.

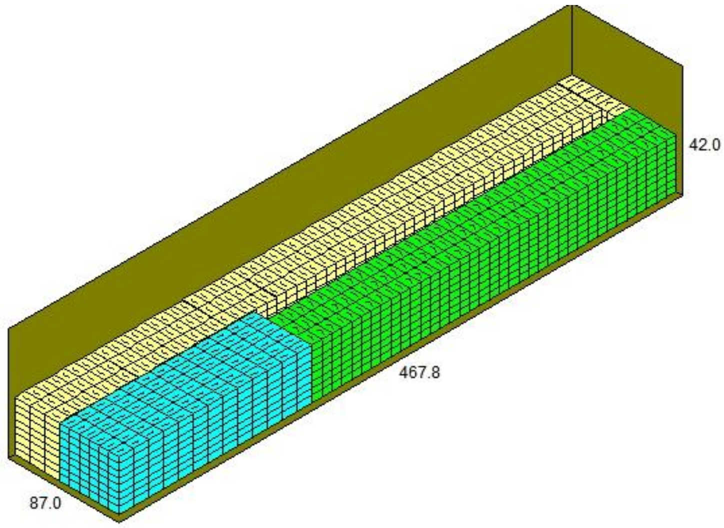

Figure 5-3 TOPS Model Equal Box Count Floor Loaded 40' Container (2880 Boxes)

Table 5-2 Equal Box Count Floor Loaded

Energy Drink Floor loaded per 40' Container	
Total product/packaging/pallet weight	43,200
Container Value	$49,766.40
Boxes per Container	2880
Cube Efficiency	37.8%

5.4 Model Output Equal Box Count

By inputting the specified data for boxes unitized on pallets and boxes floor loaded in containers, the total shipping and handling costs were obtained. An example of the display panel from the model is shown in Table 5-3 for boxes unitized on pallets and Table 5-4 for boxes floor loaded. The model was constructed in Microsoft Excel and is capable of computing up to 100 different SKUs per container without modification. Table 5-3 was created by comparing the minimum cost of forklift operators (handling unit loads) and the minimum cost of a lumper service (handling floor loaded boxes). For this example, equal cost exporter ($4.54), charge to customer was used to make the comparison. Inputs needed are bold. For this example, no additional pallets are needed by the importer for boxes arriving unitized on pallets. For floor loading, no export pallet or treatment cost is needed.

The total cost for the two loading methods is obtained by summing the outputs. Outputs are displayed as total (column one) and by SKU (column two). The output displays costs incurred throughout the export/import supply chain. For single SKU containers, the two columns are equal. Mixed SKUs use a separate column for each SKU. For this example, it is more cost efficient per container to import boxes unitized on pallets ($3,709.54), compared to floor loaded ($3,844.54). The cost difference between the two loading methods is $135.

Table 5-3 Model Display Equal Box Count Palletized

Inputs Palletized		**Value**
Individual export pallet cost		**$8.00**
Individual pallet phytosanitation cost		**$2.00**
Individual Box value		**$17.28**
Boxes per container		**2880.00**
Boxes per pallet export		**144.00**
Export pallets needed per container		**20.00**
Loading labor cost exporter per container		**$4.54**
Export drayage cost per container		**$240.00**
Shipping cost per container		**$3,000.00**
Import drayage cost per container		**$240.00**
Boxes per pallet import		**144.00**
Pallets needed per container import		**0.00**
Individual import pallet price		**$0.00**
Box demand per day		**2880.00**
Time to unload a container (hr/container)		**0.33**
Time to swap containers at a dock door (hr/container)		**0.00**
Unloading labor cost importer per container		**25.00**
Dock door capacity (hours)		**8.00**
Outputs Palletized	**Total**	**SKU 1**
Export loading cost per container	$204.54	$204.54
Export drayage cost per container	$240.00	$240.00
Shipping cost per container	$3,000.00	$3,000.00
Import drayage cost per container	$240.00	$240.00
Import unloading cost per container	$25.00	$25.00
Total cost of shipping and handling per container	$3,709.54	$3,709.54

Table 5-4 Model Display Equal Box Count Floor Loaded

Inputs Floor Loaded		**Value**
Individual export pallet cost		**$0.00**
Individual pallet phytosanitation cost		**$0.00**
Individual box value		**$17.28**
Boxes per container		**2880.00**
Boxes per pallet export		**0.00**
Export pallets needed per container		**0.00**
Loading labor cost exporter per container		**$4.54**
Export drayage cost per container		**$240.00**
Shipping cost per container		**$3,000.00**
Import drayage cost per container		**$240.00**
Boxes per pallet import		**144.00**
Pallets needed per container import		**20.00**
Individual import pallet price		**$8.00**
Box demand per day		**2880.00**
Time to unload a container (hr/container)		**2.00**
Time to swap containers at a dock door (hr/container)		**0.00**
Unloading labor cost importer per container		**200.00**
Dock door capacity (hours)		**8.00**
Outputs Floor Loaded	**Total**	**SKU 1**
Export loading cost per container	$4.54	$4.54
Export drayage cost per container	$240.00	$240.00
Shipping cost per container	$3,000.00	$3,000.00
Import drayage cost per container	$240.00	$240.00
Import unloading cost per container	$360.00	$360.00
Total cost of shipping and handling per container	$3,844.54	$3,844.54

Table 5-5 displays the cost benefit decision for the most efficient loading method (*Bfp).* The decision was made by subtracting the total costs per day of the two loading methods (*TCfcd* and *TCpcd*) from the product value per day of the two loading methods (*PVdf* and *PVdp),* resulting net values (*nVf* and *nVp*). Subtracting *nVp* from *nVf* results a net value delta or a cost benefit of utilizing pallets. In this example, the two loading methods have equal box counts per container. Both loading methods can meet demand (*Nfcd* and *Npcd*) in one container (no excess containers), which results equal container values (*Vfc* and *Vfp*). As discussed in chapter four, value has no bearing on the loading method decision. The same answer can be obtained by subtracting the total costs per day of shipping and handling for boxes unitized on pallets from the total costs per day of floor loading ($-135). Value was included to show that *PVdf* and *PVdp* can be equal. The decision needs to be based off costs meeting daily demand, not on a container basis.

Table 5-5 Equal Box Count Calculation Example

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL	$49,766.40	1.00	$49,766.40	$3,844.54	$45,921.86	-$135.00	*Consider Pallets*
P	$49,766.40	1.00	$49,766.40	$3,709.54	$46,056.86		

All cost saving benefits for the two loading methods obtained from the model for this scenario are displayed in Appendix 5 (Equal Box Count). Figure 5-4 summarizes the results. The majority of the comparisons reveal a cost benefit by unitizing boxes on pallets. Of the 72 comparisons made, only nine result a cost benefit of floor loading. The most cost efficient result for boxes unitized was made by comparing the minimum hourly forklift operator costs to maximum hourly manual labor, using variable export labor cost, and charge to customer (-$1,390). The highest observed savings for floor loading was made by comparing maximum forklift operator labor cost to minimum lumper cost, using variable export labor cost, and charge to customer ($240).

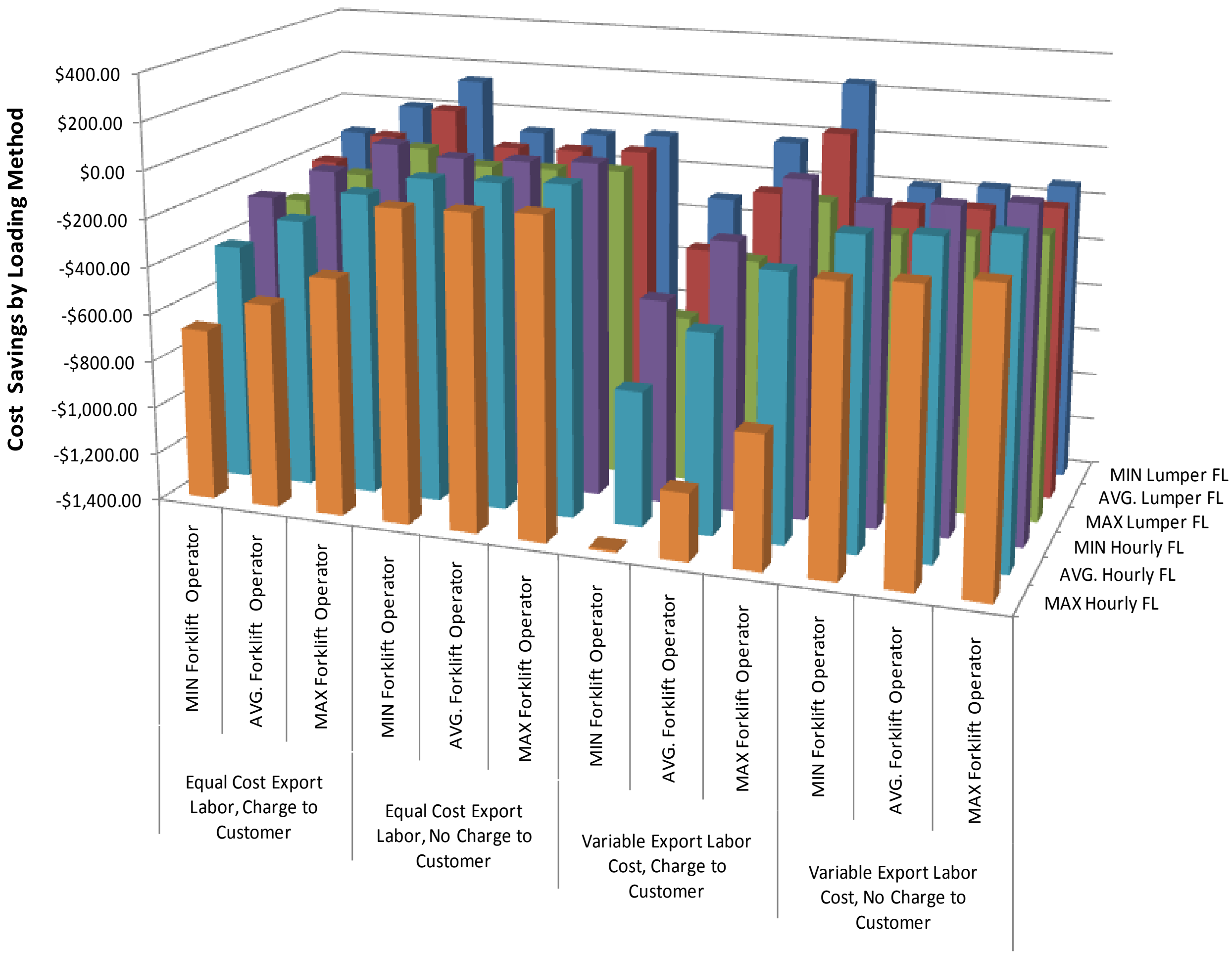

Figure 5-4 Equal Box Count Comparison

5.5 Minimal Variation in Box Count

A questionnaire respondent provided that 40'containers consist of 90 large boxes (36" (length) x 24" (width) x 32" (height)) of molded plastic parts as shown in Figure 5-5. The boxes are floor loaded and weigh 42 pounds per box. Each box contains eight products valued at $50 each for a total of $400 per box. Table 5-6 displays container weight, value, boxes per container, and cube efficiency for the container.

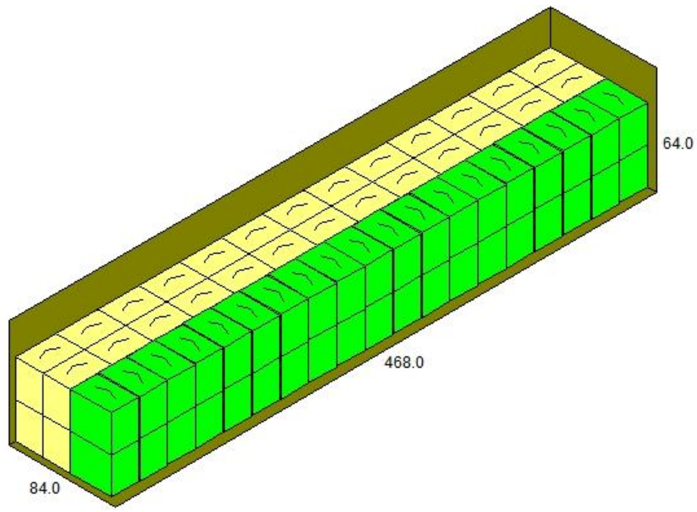

Figure 5-5 Minimal Variation in Box Count Floor Loaded 40' Container (90 Boxes)

Table 5-6 Minimal Variation in Box Count Floor Loaded (90 Boxes)

Molded Plastic Floor Loaded per 40' Container	
Total product/packaging/pallet weight	3,780 lbs.
Container Value	$36,000
Boxes per Container	90
Cube Efficiency	60.4%

Inputting the box dimensions into TOPS provided a higher floor loaded box count per container than the actual box count. By allowing various box orientations, 106 boxes optimally fit floor loaded in a 40' container. Figure 5-6 shows the box orientation to obtain 106 boxes floor loaded. Often, containers appear to be maximized with boxes upon arrival, but more boxes could fit. By floor loading, human error exists; improper placement of one box can distort the entire load. If 106 boxes were considered, the result would be different. Table 5-7 displays container weight, boxes per container, and cube efficiency for the boxes in the container.

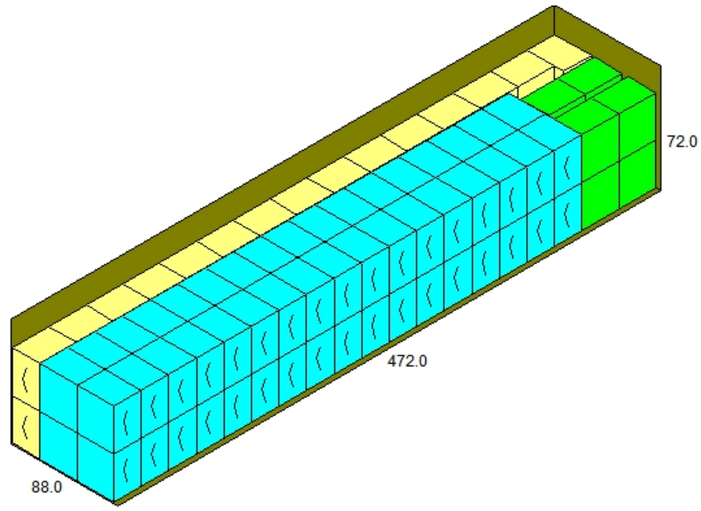

Figure 5-6 Minimal Variation in Box Count Floor Loaded 40' Container (106 Boxes)

Table 5-7 Minimal Variation in Box Count Floor Loaded (106 Boxes)

Molded Plastic Floor Loaded various orientations per 40' Container	
Total product/packaging/pallet weight	4,452 lbs.
Container Value	$42,400.00
Boxes per Container	106
Cube Efficiency	71.2%

Placing the boxes on either 48" x 40" or 1200mm x 1000mm pallets allows 84 boxes per container. The 48"x 40" pallet was selected because of its common use in the U.S.A. Figure 5-7 illustrates product fit to pallet. Figure 5-8 illustrates unitized boxes on pallets in a container. Table 5-8 shows total packaging/product weight, container value, boxes per vehicle, and cube efficiency. These results display an increased container weight, decreased box count per container, and a reduced container value.

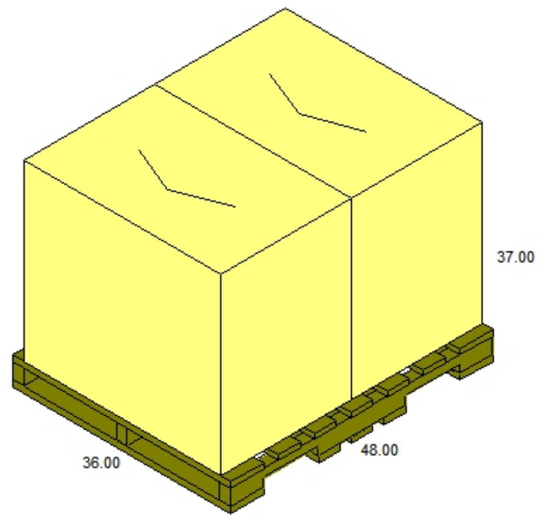

Figure 5-7 Minimal Variation in Box Count Palletized (2 Boxes)

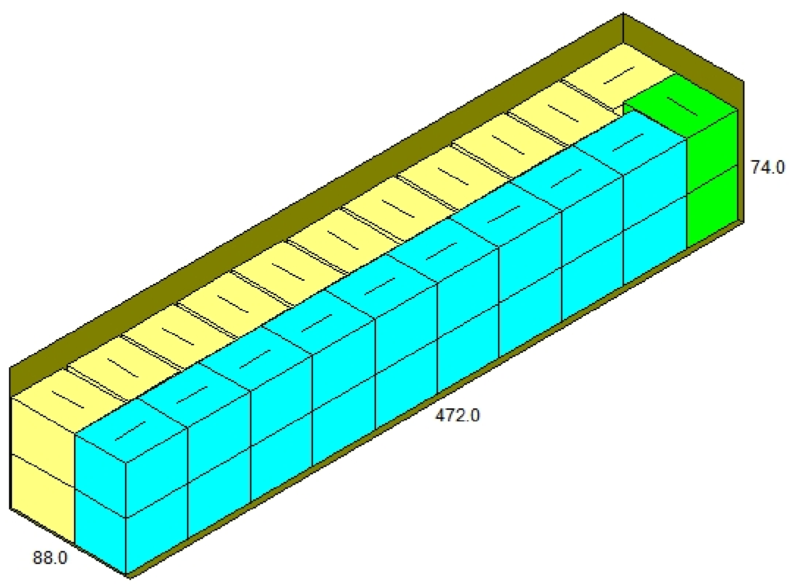

Figure 5-8 Minimal Variation in Box Count Unit Loads in a 40’ Container (84 Boxes)

Table 5-8 Minimal Variation in Box Count Palletized

Molded Plastic 48” x 40” Palletized per 40’ Container	
Total product/packaging/pallet weight	4,788 lbs.
Container Value	$33,600
Boxes per Container	84
Cube Efficiency	72.5%
Efficiency- pallet to package	90.00%

Using the actual number of floor loaded boxes received (90), six more boxes fit in a container compared to on pallets. The benefit of floor loading or palletizing, considering the various labor costs, customer charges, and additional boxes obtained by floor loading, is summarized in Figure 5-9. A complete result for minimal box difference is displayed in Appendix 6 (Minimal Variation). Of the 72 comparisons made, 15 result a cost benefit of unitizing boxes on pallets. Similar to the equal box count comparison, the highest observed value for using pallets was made by comparing minimum forklift operator cost to maximum hourly floor loaded, using variable export labor cost and charge to customer (- $1087.86). The highest observed value for floor loading was made by comparing maximum forklift operator to minimum lumper, variable export cost, charge to customer ($581.43).

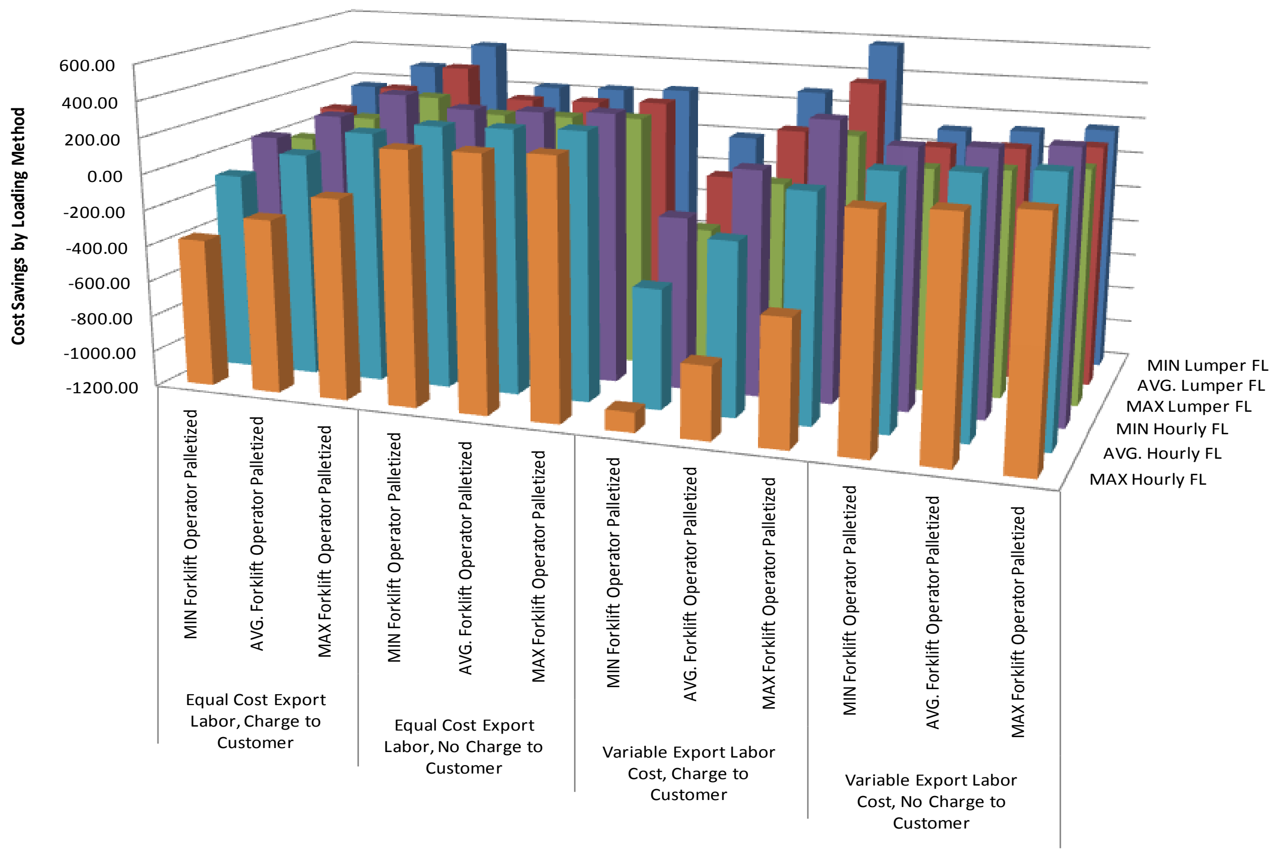

Figure 5-9 Minimal Variation in Box Count Comparison

Unlike the equal box count example displayed in Table 5-5, where demand could be met with one container for either loading method, minimal variation in box count requires excess container space for boxes unitized on pallets. Table 5-9 displays that an additional .07 container is needed for pallets to meet demand. Due to the additional container required, individual container values are different (*Vfc* and *Vpc*). However, considering product value meeting demand (*PVdf and PVdp*) the values are equal when 90 boxes are received in a day. The highest observed value of -$1,087.86 for boxes unitized on pallets was obtained by assuming only partial shipping and handling costs for the excess container.

Table 5-9 Minimal Variation in Box Count Calculation Example 1

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL	$36,000.00	1.00	$36,000.00	$5,320.00	$30,680.00	-$1,087.86	*Consider Pallets*
P	$33,600.00	1.07	$36,000.00	$4,232.14	$31,767.86		

Assuming excess container space cannot be utilized by other products, a full transport/shipping cost and a partial labor cost (unless a lumper service is utilized) was applied for the excess container needed to meet demand. Table 5-10 displays full transport/shipping costs for 2.0 containers (round 1.07 up), and labor/pallets for 1.07 containers. Net value was reduced for palletized boxes and the decision was reversed.

Table 5-10 Minimal Variation in Box Count Calculation Example 2

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL	$36,000.00	1.00	$36,000.00	$5,320.00	$30,680.00	$2,425.70	*Consider Floor Loading*
P	$33,600.00	1.07	$36,000.00	$7,463.56	$28,536.00		

Comparisons were made for boxed products meeting demand in one floor loaded container, which resulted 1.07 containers palletized. From the data collected in this study, the minimum, average, and maximum containers arriving per day were one, six, and 35, respectively. By increasing demand to six for partial charged containers (results 6.43 containers when import is unitized on pallets), the cost benefit of using pallets is -$7,770.00 as displayed in Table 5-11. The total cost to meet demand floor loaded (*TCfcd*) is greater than the total cost to meet demand palletized (*TCpcd*), resulting a greater *Nvp* than *Nvf*. Only partial shipping and handling costs are applied for the excess container (full charge for the six full containers and partial charge for the additional 0.43 use of the excess container). In Table 5-12, full transport and shipping costs are applied for the excess container (charged for seven transport/shipping and 6.43 for labor and pallets). By increasing container demand, a cost benefit still exists for boxes unitized on pallets, even when an excess container exists and is charged in full.

Table 5-11 Minimal Variation in Box Count Calculation Example 3

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL	$36,000.00	6.00	$216,000.00	$31,920.00	$184,080.00	-$7,770.00	*Consider Pallets*
P	$33,600.00	6.43	$216,000.00	$24,150.00	$191,850.00		

Table 5-12 Minimal Variation in Box Count Calculation Example 4

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL	$36,000.00	6.00	$216,000.00	$31,920.00	$184,080.00	-$4,538.58	*Consider Pallets*
P	$33,600.00	6.43	$216,000.00	$27,381.42	$188,618.58		

5.6 Medium Variation in Box Count

The selected product was imported floor loaded. The product is seafood. Normally, a refrigerated container (reefer container) would be used and regulations prohibit seafood from being palletized in containers. For this research, seafood was treated as a regular boxed product. A non-refrigerated container was used. Box dimensions of 24" (length) x 11" (width) x 6" (height) were put into TOPS. A container weight of 60,000 pounds was obtained. This weight resulted from 40 pounds per box and 1500 boxes per container. Special/overweight permits are likely for the specified product. The highest payload rating for an ISO container is 58,870 pounds. Figure 5-10 displays the boxes in the container. Each box of seafood was valued at $72 each. Table 5-13 displays product weight per container, container value, boxes per container, and container cube efficiency. Since 1500 boxes did not cube out the container, an attempt was made to utilize a 20' container, as shown in Figure 5-11. Table 5-14 shows that 1500 boxes cannot fit inside a 20' container.

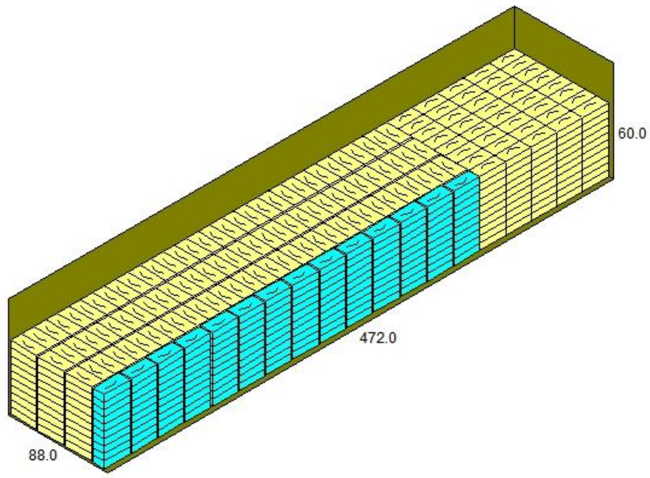

Figure 5-10 Medium Variation in Box Count Floor Loaded 40' Container (1500 Boxes)

Table 5-13 Medium Variation in Box Count Floor Loaded

Seafood Floor Loaded 40' Container	
Total product/packaging/pallet weight	60,000
Container Value	$108,000
Boxes per Container	1500
Cube Efficiency	57.7%

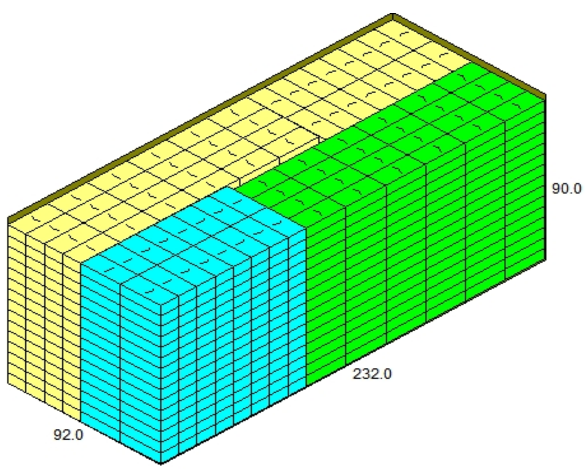

Figure 5-11 Medium Variation in Box Count Floor Loaded 20' Container (1200 Boxes)

Table 5-14 Medium Variation in Box Count Floor Loaded 20' Container

Seafood Floor Loaded 20' Container	
Total product/packaging/pallet weight	48,000 lbs.
Container Value	$86,400.00
Boxes per Container	1200
Cube Efficiency	94.4%

Boxes were placed on 1200 mm x 1000 mm pallets as shown in Figure 5-12. The pallet configuration used provided the best box fit to pallet and allowed the highest box count per container palletized. Figure 5-13 displays pallets in container, followed by Table 5-15, which displays the details of the container.

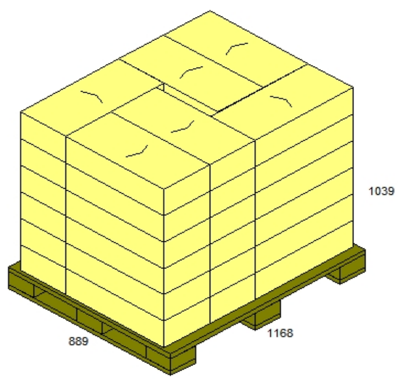

Figure 5-12 Medium Variation in Box Count Palletized (36 Boxes)

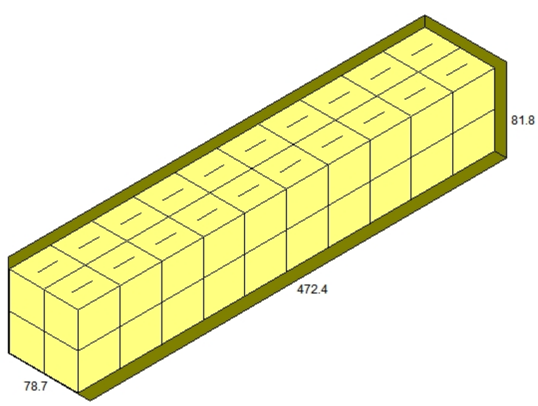

Figure 5-13 Medium Variation in Box Count Unit Loads 40' Container (1440 Boxes)

Table 5-15 Medium Variation in Box Count Palletized 40' Container

Seafood 1200mm x 1000mm Palletized 40' Container	
Total product/packaging/pallet weight	58,800 lbs.
Container Value	$103,680.00
Boxes per Container	1440
Cube Efficiency	73.98%
Efficiency- pallet to package	85.16%

Even though 60 additional boxes can be obtained by floor loading, the results of the model show benefit opportunities to import boxes in unitized form. From the 72 comparisons made, 25 result a cost benefit by unitizing on pallets. A complete result for medium box difference is displayed in Appendix 7 (Medium Variation). The results are summarized in Figure 5-14. The highest observed savings by utilizing pallets was -$1,202.25, obtained by comparing minimum forklift operator to maximum hourly floor loaded, using variable export labor cost, and charge to customer. The highest cost benefit for floor loading was $450.67, obtained by comparing maximum forklift operator to minimum lumper, variable export cost, charge to customer.

More cost benefit opportunities exist by using pallets when comparing minimum box difference to medium box count difference. The difference is derived from the following:

- For minimum box count difference, three pallets are needed to meet demand compared to two for medium box count difference. The additional pallet results an additional cost.
- The additional pallet occupies space in the container. Considering a partial charge (transport and labor), less space occupied in a container results a lowered cost.
- More labor would be needed to unload the medium box count (60 additional boxes compared to six additional boxes).

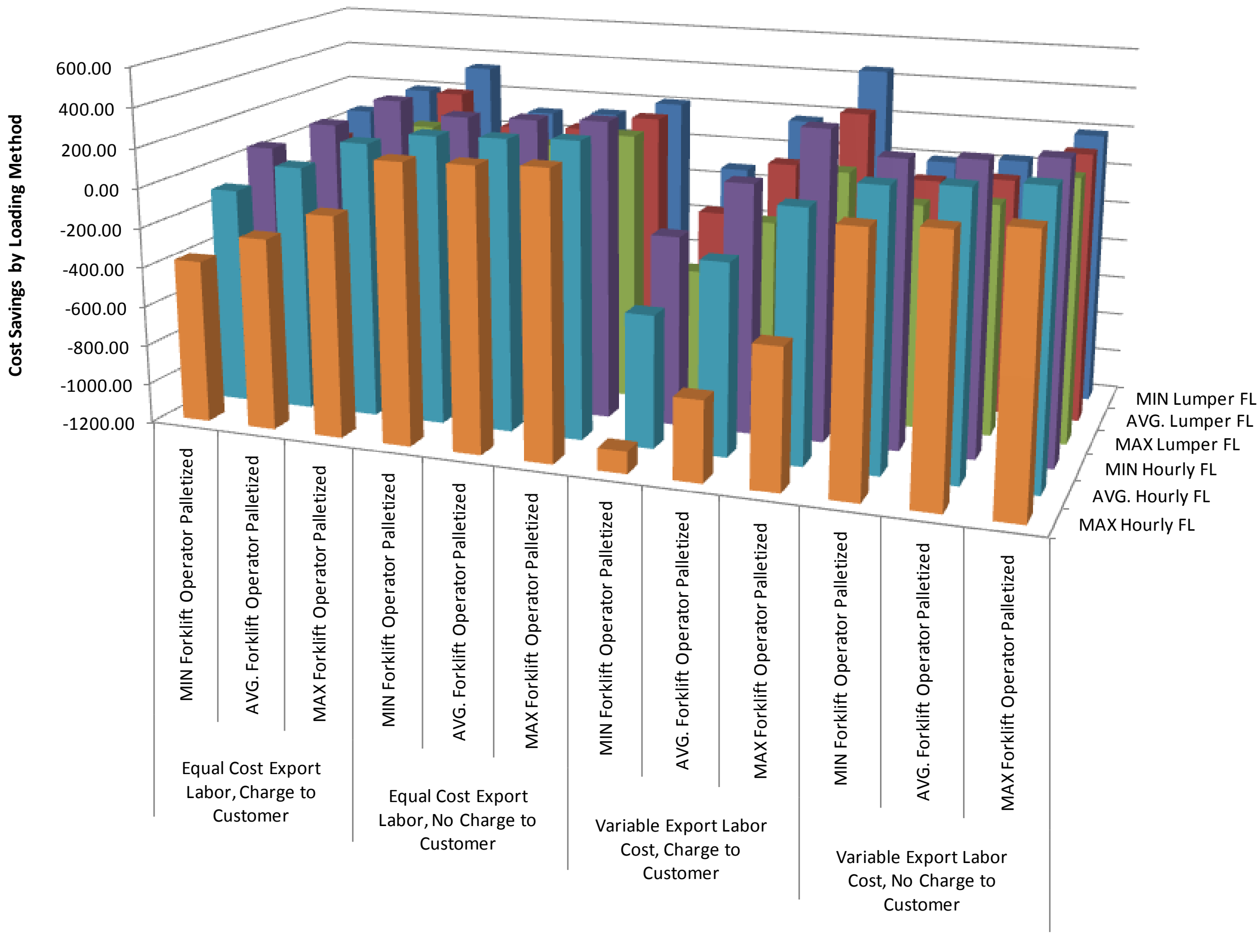

Figure 5-14 Medium Variation in Box Count Comparison

5.7 Large Variation in Box Count

The same box dimensions used for medium variation in box count were applied to large variation in box count. Box weight was reduced to 15 pounds, which allowed 2,460 boxes per container floor loaded. Figure 5-15 displays the boxes in a container. Table 5-16 displays container weight, value, boxes per container and cube efficiency.

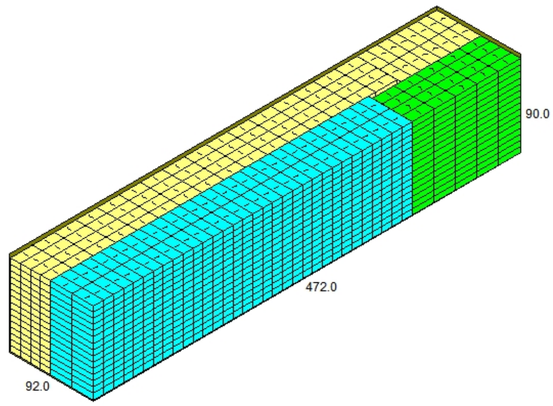

Figure 5-15 Large Variation in Box Count Floor Loaded 40’ Container (2460 Boxes)

Table 5-16 Large Variation in Box Count Floor Loaded 40’ Container

Seafood 1200mm x 1000mm Palletized 40’ Container	
Total product/packaging/pallet weight	36,9000 lbs.
Container Value	$177,120
Boxes per Container	2460
Cube Efficiency	94.69%

The same pallet configuration shown in Figure 5-12 was used. Reducing the box weight to 15 pounds allowed 42 unit loads per container compared to 40. Figure 5-16 displays unit loads in a container, followed by Table 5-17 which provides: container weight, value, boxes per container, cube efficiency, and box to pallet efficiency.

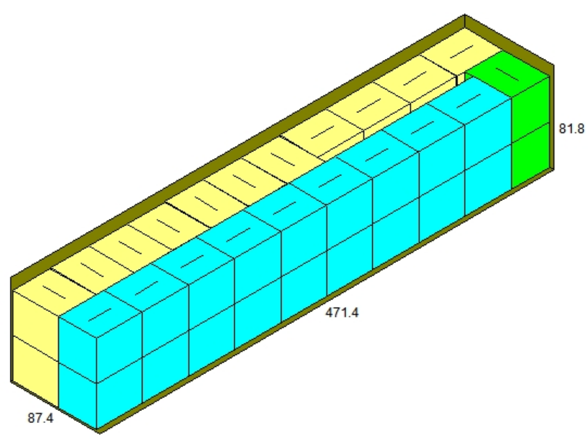

Figure 5-16 Large Variation in Box Count Unit Loads 40’ Container (1512 Boxes)

Table 5-17 Large Variation in Box Count Palletized 40' Container

Seafood 1200mm x 1000mm Palletized 40' Container	
Total product/packaging/pallet weight	23,940 lbs.
Container Value	$108,864
Boxes per Container	1512
Cube Efficiency	78.92%
Efficiency- pallet to package	85.16%

The complete results of the model for the various labor and customer charges are displayed in Appendix 8 (large variation). Figure 5-17 summarizes the results. The comparison revealed no cost benefit of palletizing. The nearest value to result a benefit of using pallets is $914.59 in favor of floor loading.

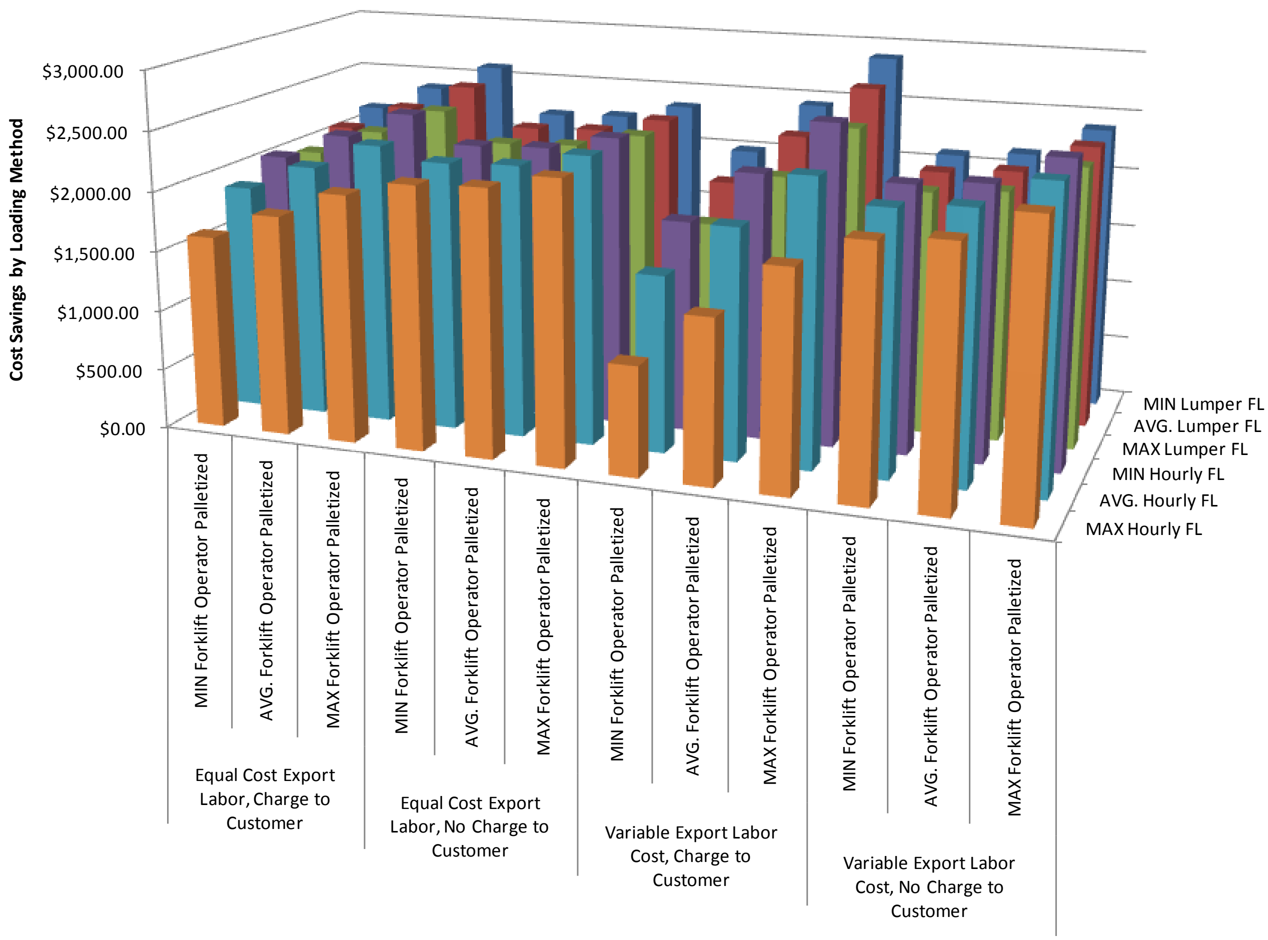

Figure 5-17 Medium Variation in Box Count Comparison

5.8 Mixed Container

Dimensions are needed for each varying SKU. Inputting the dimensions of 18.13” x 12.25” x 10.38” for Product1, 22.5” x 12.63” x 9.75” for Product2, and 8.75” x 8.25” x 8.38” for Product3 into MaxLoad results the loading configuration shown in Figure 5-18. Figure 5-19 illustrates boxes unitized on pallets in the container.

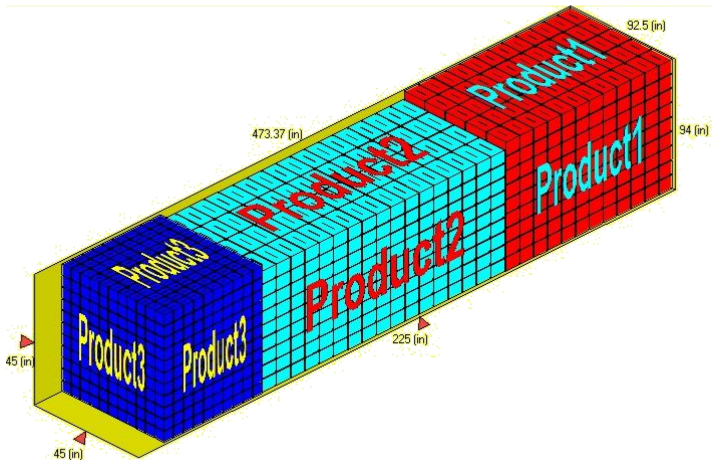

Figure 5-18 Mixed SKU Floor loaded 40' Container (2362 Boxes)

An assumed demand is shown in Table 5-18. It can be observed that boxes per container equal box demand floor loaded.

Table 5-18 Mixed SKU Floor Loaded Box Demand, Boxes per Container

Floor Loaded	Boxes per Container	Daily Box Demand
SKU 1	540	540
SKU 2	612	612
SKU3	1210	1210

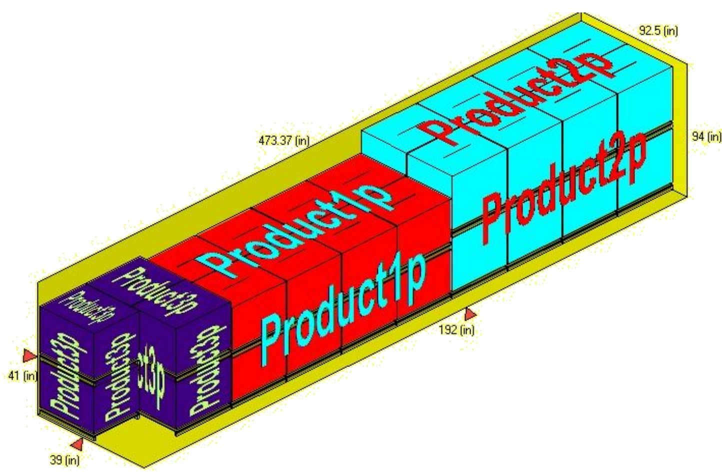

Figure 5-19 Mixed SKU Unit Loads 40' Container (1360 Boxes)

For boxes unitized on pallets, demand cannot be met in one container, as floor loading can. Table 5-19 displays allowable boxes per container palletized.

Table 5-19 Mixed SKU Palletized Box Demand, Boxes per Container

Palletized	Boxes per Container	Daily Box Demand
SKU 1	336	540
SKU 2	384	612
SKU3	640	1210

The model provides a breakdown of costs throughout the export/import supply chain for each individual varying SKU. Tables 5-20 and 5-21 display the costs per container for floor loaded boxes and the cost per container for boxes unitized on pallets, respectively. In this example, SKU 3 had the highest box count per container, and highest demand. However, the boxes are small and occupy the least amount of container volume. The remaining calculations were made for this select example and are displayed in Table 5-22. The results of all comparisons for mixed SKU containers are displayed in Appendix 9 (SKU 1,) Appendix 10 (SKU 2), and Appendix 11 (SKU 3).

A cost savings benefit was observed for SKU3 for boxes unitized on pallets in 38 of the 72 comparisons. Due to the number of boxes of SKU 3, the labor cost was higher than the other SKUs for floor loaded containers. The labor cost of SKU 3 was the lowest of the three SKUs when unitized on pallets, due to the number of boxes per pallet. For SKU1 and SKU2, all comparisons result a cost savings benefit by floor loading, due to the occupied container volume. Reduced forklift operator costs could not offset the labor and shipping charge of boxes floor loaded, due to the excess container required.

Since a cost savings was observed for SKU3, a calculation should be made by placing the boxes on pallets in a floor loaded container with SKU1 and SKU2 boxes. The useable container volume for boxes floor loaded should be considered. In this, the total cost of shipping and drayage is proportional to space occupied. The decision may again be reversed for the boxes unitized, as it may distort the load of SKU1 and SKU2, resulting in additional containers to be needed and higher costs. Additionally, consideration to convert SKU3 to a single SKU container should be made through single SKU calculations.

Table 5-20 Model Display Mixed SKU Container Floor Loaded

Inputs Floor Loaded	Value			
Individual export pallet cost		$0.00	$0.00	$0.00
Individual pallet phytosanitation cost		$0.00	$0.00	$0.00
Individual carton value		$100.00	$85.00	$10.00
Boxes per container		540.00	612.00	1210.00
Boxes per pallet export		0.00	0.00	0.00
Export pallets needed per export container		0.00	0.00	0.00
Individual Box Volume		1.33	1.60	0.35
Box volume per container		718.20	979.20	423.50
% of Container Used		33.86%	46.17 %	19.97%
Box volume per day		718.20	979.20	423.50
Loading labor cost exporter per container		$4.54	$4.54	$4.54
Export drayage cost per container		$240.00	$240.00	$240.00
Shipping cost per container		$3,000.00	$3,000.00	$3,000.00
Import drayage cost per container		$240.00	$240.00	$240.00
Boxes per pallet import		21.00	24.00	80.00
Pallets needed per container import		26.00	26.00	16.00
Individual import pallet price		$8.00	$8.00	$8.00
Boxes demand per day		540.00	612.00	1210.00
Time to unload a container (hr/container)		2.00	2.00	2.00
Time to swap containers at a dock door (hr/container)		0.00	0.00	0.00
Unloading labor cost importer per container		200.00	200.00	200.00
Dock door capacity (hours)		8.00	8.00	8.00
Outputs Floor Loaded	**Total**	**SKU 1**	**SKU 2**	**SKU 3**
Export loading cost per container	$4.54	$1.04	$1.18	$2.33
Export drayage cost per container	$240.00	$81.27	$110.81	$47.92
Shipping cost per container	$3,000.00	$1,015.89	$1,385.07	$599.04
Import drayage cost per container	$240.00	$81.27	$110.81	$47.92
Import unloading cost per container	$744.00	$253.72	$259.82	$230.46
Total cost of shipping and handling per container	$4,228.54	$1,433.19	$1,867.68	$927.67

Table 5-21 Model Display Mixed SKU Container Palletized

Inputs Palletized	Value			
Individual export pallet cost		$8.00	$8.00	$8.00
Individual pallet phytosanitation cost		$2.00	$2.00	$2.00
Individual box value		$100.00	$85.00	$10.00
Boxes per container		336.00	384.00	640.00
Boxes per pallet export		21.00	24.00	80.00
Export pallets needed per container		16.00	16.00	8.00
Individual box and pallet volume		32.75	43.40	32.65
Total box and pallet volume per container		524.00	694.40	261.20
% of container used		35.41%	46.93%	17.65%
Pallets needed per day		26.00	26.00	16.00
Volume of boxes and pallets per day		851.50	1128.40	522.40
Total container volume required to meet demand		0.58	0.76	0.35
Loading labor cost exporter per container		$4.54	$4.54	$4.54
Export drayage cost per container		$240.00	$240.00	$240.00
Shipping cost per container		$3,000.00	$3,000.00	$3,000.00
Import drayage cost per container		$240.00	$240.00	$240.00
Box per pallet import		21.00	24.00	80.00
Pallets needed per container import		0.00	0.00	0.00
Individual import pallet price		$0.00	$0.00	$0.00
Box demand per day		540.00	612.00	1210.00
Time to unload a container (hr/container)		0.33	0.33	0.33
Time to swap containers at a dock door (hr/container)		0.00	0.00	0.00
Unloading labor cost importer per container		25.00	25.00	25.00
Dock door capacity (hours)		8.00	8.00	8.00
Outputs Palletized	**Total**	**SKU 1**	**SKU 2**	**SKU 3**
Export loading cost per container	$404.54	$161.82	$161.82	$80.91
Export drayage cost per container	$240.00	$85.00	$112.64	$42.37
Shipping cost per container	$3,000.00	$1,062.45	$1,407.95	$529.60
Import drayage cost per container	$240.00	$85.00	$112.64	$42.37
Import unloading cost per container	$25.00	$10.00	$10.00	$5.00
Total cost of shipping and handling per container	$3,909.54	$1,404.26	$1,805.04	$700.25

Table 5-22 Mixed SKU Calculation Example

	Vfc Vpc	Nfcd Npcd	PVdf PVdp	TCfcd TCpcd	nVf nVp	Bfp	Cost Based Decision
FL SKU1	$54,000.00	0.34	$54,000.00	$1,433.19	$52,566.81	$779.20	*Consider Floor Loading*
P SKU1	$33,600.00	0.58	$54,000.00	$2,212.40	$51,787.60		
	Vfc Vpc	**Nfcd Npcd**	**PVdf PVdp**	**TCfcd TCpcd**	**nVf nVp**	**Bfp**	**Cost Based Decision**
FL SKU2	$52,020.00	0.46	$52,020.00	$1,867.68	$50,152.32	$1,313.94	*Consider Floor Loading*
P SKU2	$32,640.00	0.76	$52,020.00	$3,181.63	$48,838.37		
	Vfc Vpc	**Nfcd Npcd**	**PVdf PVdp**	**TCfcd TCpcd**	**nVf nVp**	**Bfp**	**Cost Based Decision**
FL SKU3	$12,100.00	0.20	$12,100.00	$927.67	$11,172.33	$19.82	*Consider Floor Loading*
P SKU3	$6,400.00	0.35	$12,100.00	$947.48	$11,152.52		

5.9 Dock Door Capacity

Once a cost benefit by either floor loading or palletizing is obtained, it must be determined whether the boxed products can be unloaded to meet demand. The minimum, average, and maximum containers received per day from the data collected were one, six, and 35, respectively. IDCs and 3PLs are responsible for receiving and unloading an array of containers from several manufactures destined for various locations, in addition to top imported products. From data collected, minimum, average, and maximum receiving dock doors were found to be four, 29, and 160, respectively. Table 5-23 displays time in hours to unload containers. The unloading times are displayed as minimum, average, and maximum work hours for the various labor types. The maximum forklift operator time was based on pallets loaded with super sacks. Through observations during field studies, super sacks on pallets can be problematic to unload. The maximum forklift operator time was used in the study to demonstrate a worst case scenario.

Table 5-23 Time to Unload Containers Various Labor

Labor Service	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	2	3.2	4
Hourly Floor Loaded	2	2.75	4
Forklift Operator Palletized	0.33	0.84	2

The determination of the number of dock doors needed is relevant for facilities that do not have large numbers of receiving doors, for facilities interested in accepting new products, or for facilities expecting an increase in demand for an existing product. Live loads/live unloads are commonly used when container contents are palletized. However, when too many containers arrive simultaneously at a facility without enough doors to handle the volume, some containers may have to be dropped, regardless of whether the contents are palletized or not. Facilities that don't have enough doors to handle the number of containers per day have to move containers out once unloaded so other containers can utilize the door. Field studies revealed that 15 minutes is required to move one container away from a door and move another to the door. This delay is added to time to unload. Eight hours is the maximum available time for each door.

Tables 5-24, 5-25, and 5-26 display the number of doors needed to unload one, six, and 35 containers of product, respectively. Results are displayed as fractional door and/or whole doors needed to meet daily demand for a specified product. Lumper time to unload floor loaded boxes, hourly time to unload floor loaded boxes, and forklift operator time to unload boxes in unitized form are combined for each container demand comparison.

Table 5-24 Receiving Doors Needed to Unload One Container

1 Container	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	0.29	0.44	0.54
Hourly Floor Loaded	0.29	0.38	0.54
Forklift Operator Palletized	0.08	0.14	0.29

Table 5-25 Receiving Doors Needed to Unload Six Containers

6 Containers	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	1.69	2.59	3.19
Hourly Floor Loaded	1.69	2.25	3.19
Forklift Operator Palletized	0.44	0.82	1.69

Table 5-26 Receiving Doors Needed to Unload 35 Containers

35 Containers	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	9.85	15.1	18.6
Hourly Floor Loaded	9.85	13.13	18.6
Forklift Operator Palletized	2.54	4.77	9.85

The results from Tables 5-24 through 5-26 show that fewer doors are needed when boxes are imported palletized, compared to floor loaded. The minimum doors needed for floor loaded boxes equals the maximum number of doors needed palletized.

Often, the number of boxes palletized is less than the number of boxes floor loaded per container. This results in the need for additional containers when importing palletized boxes. Utilizing 35 containers and the data from minimal variation in box count (90 boxes floor loaded, 84 palletized) results in 35 containers floor loaded and 37.5 containers palletized to meet demand of 3150 boxes. Table 5-27 displays that, even with the increase in containers, dock door efficiency is greater when boxes are imported palletized.

Table 5-27 Doors Needed for 35 Containers Floor Loaded 37.5 Doors Palletized

35 Containers Floor Loaded, 37.5 Containers Palletized	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	9.85	15.1	18.6
Hourly Floor Loaded	9.85	13.13	18.6
Forklift Operator Palletized	2.71	5.11	10.55

5.10 Maximum Containers per Receiving Dock Door

For high demand boxed products, facilities may need to obtain as many boxed products as possible per day. For this case, the maximum number of boxed products that can be unloaded per day must be determined. To unload as many containers as possible in an eight hour day, a 15 minute delay was considered for a facility utilizing one door and a facility utilizing 160 doors to unload as much product as possible, assuming each door has eight hours of availability. Utilizing 160 doors for a given product is unlikely, and was incorporated in this study for demonstration purposes. Table 5-28 and 5-29 display the results for use of one door and 160 doors, respectively.

Table 5-28 Maximizing Container Throughput One Receiving Door

Per 1 Door (Assumes Delay)	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	3.55	2.31	1.88
Hourly Floor Loaded	3.55	2.66	1.88
Forklift Operator Palletized	13.79	7.33	3.55

Table 5-29 Maximizing Container Throughput 160 Receiving Doors

Per 160 Doors (Assumes Delay)	Minimum Time Work Hours	Average Time Work Hours	Maximum Time Work Hours
Lumper Floor Loaded	568.88	371.01	301.17
Hourly Floor Loaded	568.88	426.66	301.17
Forklift Operator Palletized	2206.89	1174.31	568.88

Throughput of boxed products increases when imports are palletized upon arrival. The highest observed container quantity for floor loaded boxes utilizing one door was 3.55 containers per door. The highest container quantity for palletized boxes utilizing one door was 13.79. Using similar box count (90 boxes floor loaded and 84 palletized) results in a product value per container of $36,000 floor loaded and $33,600 palletized. Value per day using one dock door was \$127,800 for floor loaded boxes and \$463,344 for palletized boxes. Costs to receive and unload floor loaded product was \$18,886. Cost to receive and unload boxes palletized was \$54,470.50. Using the equation to determine net value delta, the product value increase by palletizing was determined.

$$\$108{,}914.00 - \$408{,}873.5 = \$ - 299{,}959.50$$

In this example, when the goal is to obtain as much product as possible per door, per day, nearly \$300,000 of additional product can be received palletized compared to floor loaded.

5.11 Model Sensitivity Analysis

Through data collection, forklift operators were found to be the most efficient in terms of cost and time on a container basis. However, comparing floor loaded containers to containers with contents palletized; it is unlikely demand will be met in full containers. Unitizing boxes on pallets often requires an excess container to meet daily box demand. Excess containers are charged full shipping, drayage and partial labor costs, or partial shipping, drayage and partial labor. Shipping constitutes the highest cost in the export/import supply chain. A sensitivity analysis was performed to determine the impact of labor cost and pallet cost on the cost savings by loading method. Through conducting the simulations, the impact of the number of boxes per container by loading method, container demand, and excess containers were addressed. To test the sensitivity of the model, assumptions were made for each case analyzed.

5.11.1 Assumptions to Determine the Impact of Labor

The first case considered the impact of labor on the overall cost savings. Minimal and large box count variations (minimal box count variation is 90 boxes floor loaded to 84 boxes unitized on pallets, large box count variation is 2460 floor loaded to 1512 boxes unitized on pallets) were simulated for the two loading methods. Additionally, container demand was increased from one floor loaded container to 35 floor loaded containers (obtained through data collection as a minimum and maximum amount of containers per day). For both box count variations, equal export labor costs for both loading methods were assumed. Pallet costs were assumed equal for exporters and importers. Pallets were assumed to be constructed of wood. A phytosanitation cost per pallet was considered for export pallets. Data collected from questionnaires on labor rates for forklift operators, lumper services, and hourly manual labor were used for the comparisons.

5.11.2 Impact of Forklift Operator and Lumper Labor One Container

The minimum and maximum forklift operator labor costs, considering a profit were compared to the minimum and maximum lumper labor costs, considering a profit, as shown in Figure 5-20. As the labor rate for one loading method increases, the cost savings of that loading method decreases. A cost savings benefit for floor loading or unitizing on pallets occurs above or below the point of intersection on the x axis, respectively. For this case, a cost savings benefit of using pallets exists when a forklift operator labor cost is $25 dollars or less (considering profit) to unload a container and lumper labor cost is $365.68 or greater (considering a profit). Considering the actual range obtained from questionnaires ($25 minimum forklift operator labor compared to $390 maximum lumper labor), a cost savings of $-24.32 is obtained for boxes unitized on pallets. To meet demand, an additional seven percent of an excess container is needed for boxes unitized on pallets.

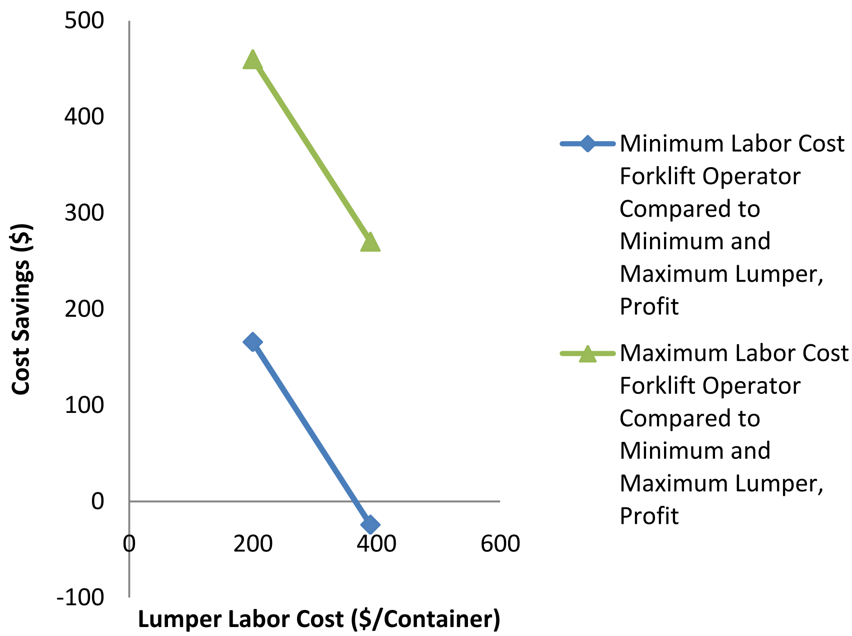

Figure 5-20 Forklift Operator to Lumper Labor Cost Comparison for One Container

5.11.3 Impact of Forklift Operator and Lumper Labor for One Container

The cost savings benefit determined in Figure 5-20 increases as container demand increases, as shown in Figure 5-21. In this case, floor loaded container demand was increased to 35 containers, resulting in 37.5 containers for boxes unitized on pallets.

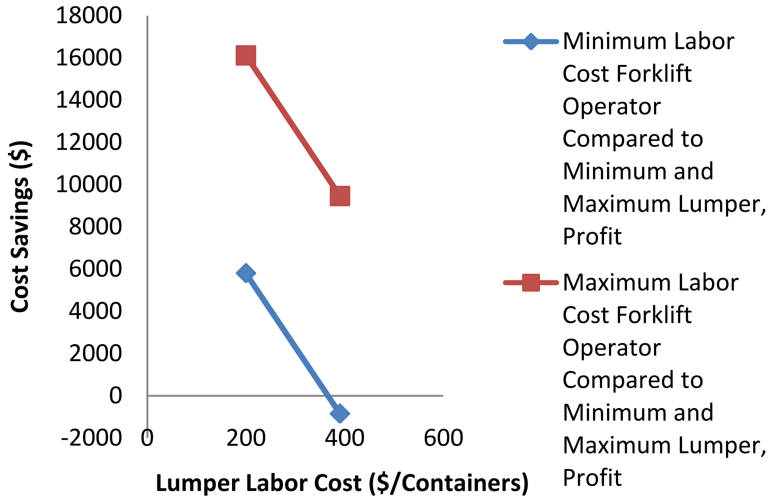

Figure 5-21 Forklift Operator to Lumper Labor Cost Comparison for 35 Containers

5.11.4 Impact of Forklift Operator and Hourly Labor One Container

The other type of manual labor identified through this research was hourly. A cost savings benefit by unitizing on pallets is more likely when comparing forklift operator labor to hourly labor (rather than forklift operator labor to lumper labor). Figure 5-22 illustrates that due to the high cost of hourly manual labor (considering a profit); a cost savings benefit is possible by using pallets, even considering maximum forklift operator labor costs. Considering the range of labor obtained from questionnaires, a cost savings does not exist for boxes unitized on pallets when forklift operator labor is $300 or greater and hourly labor cost is $312 or less.

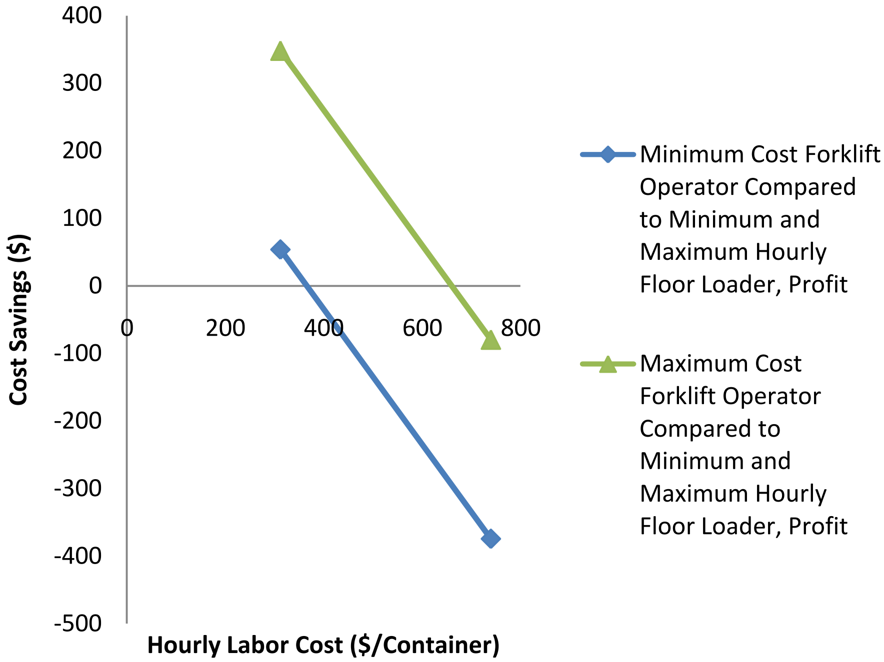

Figure 5-22 Forklift Operator to Hourly Labor Cost Comparison for One Container #1

5.11.5 Impact of Forklift Operator and Hourly Labor 30 Containers

For this example, the amount of containers needed to meet demand is the same as the comparison made in Figure 5-21 (35 containers floor loaded, 37.5 containers with contents palletized). However, as container demand increases, considering hourly labor, a greater cost savings benefit is observed. Comparing the minimum forklift operator labor cost to the maximum hourly labor cost results in a cost savings benefit of $-13,100 for pallets, as shown in Figure 5-23. In this case, considering the boundaries obtained through questionnaires, a cost savings benefit is possible for boxes unitized on pallets, even if a full container charge is implemented for the excess container.

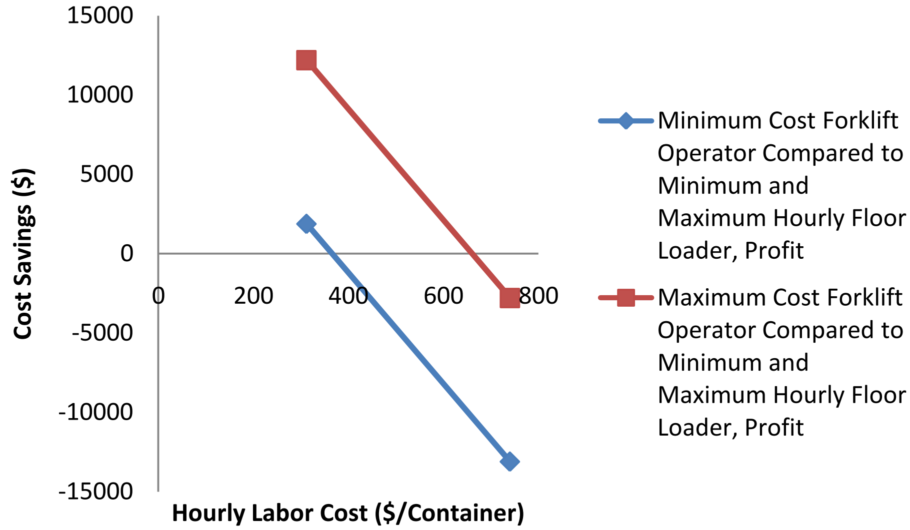

Figure 5-23 Forklift Operator to Hourly Labor Cost Comparison for 35 Containers

5.11.6 Impact of Labor on Large Box Count Variation

In another simulation, decreasing the box dimensions potentially (weight dependent) allows more boxes per single SKU floor loaded container. For this example, 2460 boxes fit in a floor loaded container, which results in a maximum of 1512 boxes palletized (large box count variation between loading methods). An excess container is needed for boxes unitized on pallets to meet demand. Unlike the above examples where seven percent of an excess container was needed, 63 percent of an excess container is needed for this simulation. In this case, minimum and maximum forklift operator labor was compared to minimum and maximum hourly manual labor, as shown in Figure 5-24. Considering the range of labor costs from questionnaires, a cost savings benefit of using pallets is not possible.

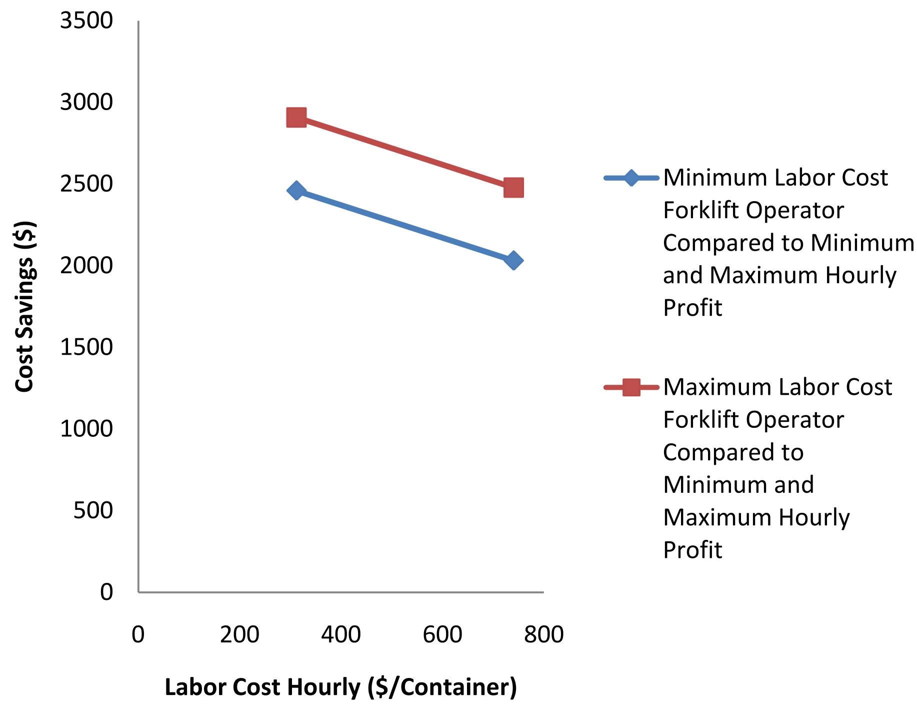

Figure 5-24 Forklift Operator to Hourly Labor Cost Comparison for One Container #2

5.11.7 Assumptions to Determine the Impact of Pallet Cost

Through this research, pallets were found to cost an IDC eight dollars each. Fluctuations in pallet prices exist. To demonstrate the sensitivity of the model in regard to pallet price, the minimum and maximum labor rates for forklift operators, lumper, and hourly manual labor were simulated assuming high ($14) and low ($2) import pallet costs. Export pallet costs were assumed equal for the comparisons. However, a phytosanitation cost was considered for export pallets. The comparisons consider minimal box count variation and large box count variation.

5.11.8 Impact of Pallet Cost, Forklift Operator and Lumper Labor

For minimal variation in box count between loading methods, a higher import pallet price ($14) results in an increased cost savings for boxes unitized on pallets compared to floor loaded. Using the assumed range of pallet costs, a cost savings benefit for boxes unitized on pallets is not possible when the pallet cost is reduced ($2). The results are shown in Figure 5-25.

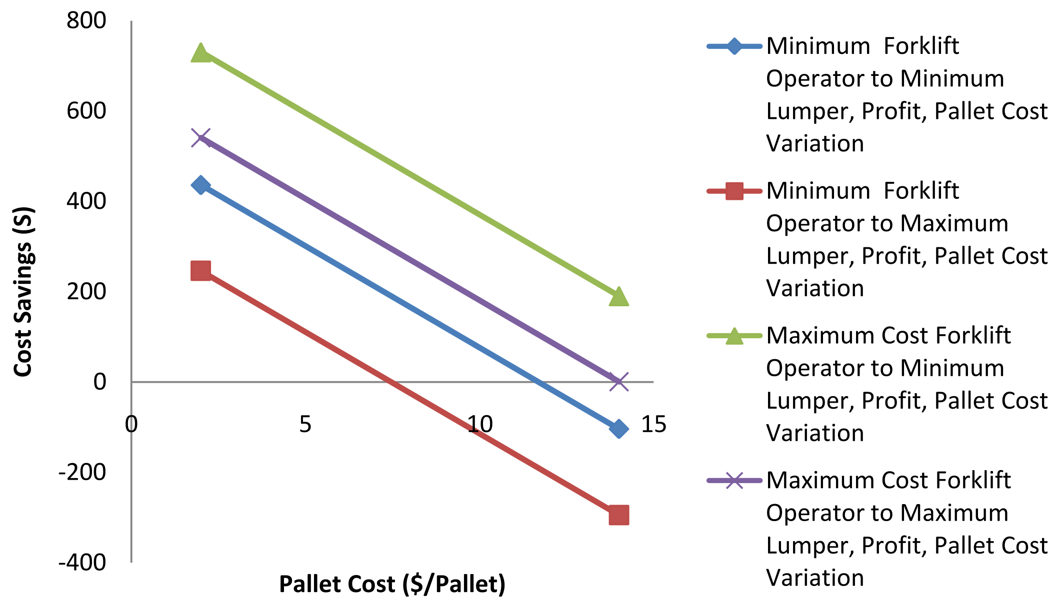

Figure 5-25 Pallet Cost Influence Forklift Operator Labor and Lumper Labor Cost

5.11.9 Impact of Pallet Cost, Forklift Operator and Hourly Labor

As the cost of manual labor increases, pallet cost has a greater influence on the cost savings. Using the assumed range of pallet costs and comparing low forklift labor (considering a profit) to high hourly labor (considering a profit), a cost savings benefit is not possible for boxes floor loaded, as shown in Figure 5-26.

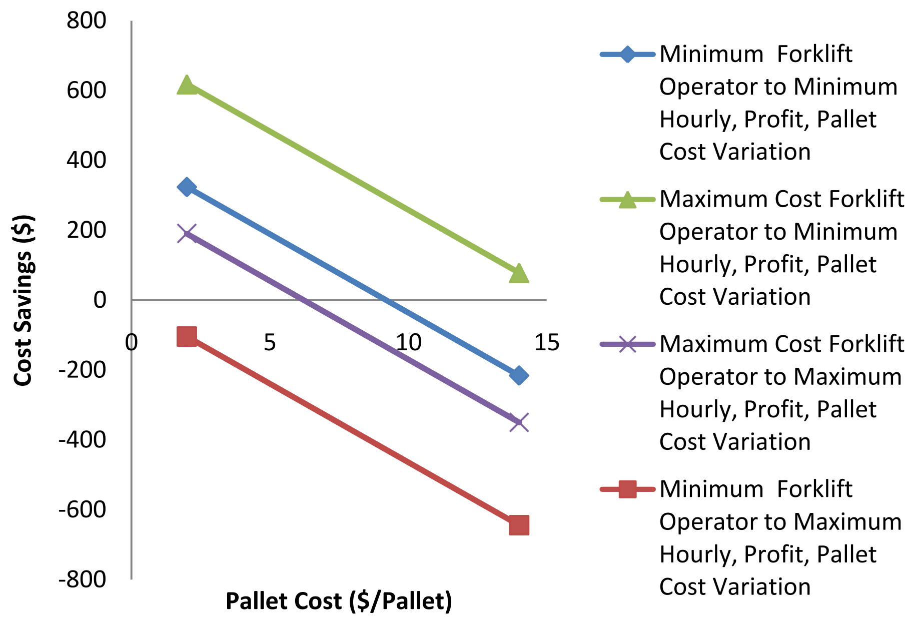

Figure 5-26 Pallet Cost Influence Forklift Operator to Hourly Labor Cost

As more space in an excess container is needed to meet demand (63 percent occupied), the cost of pallets is not significant enough to result in a cost savings benefit for boxes unitized on pallets, as shown in Figure-5-27.

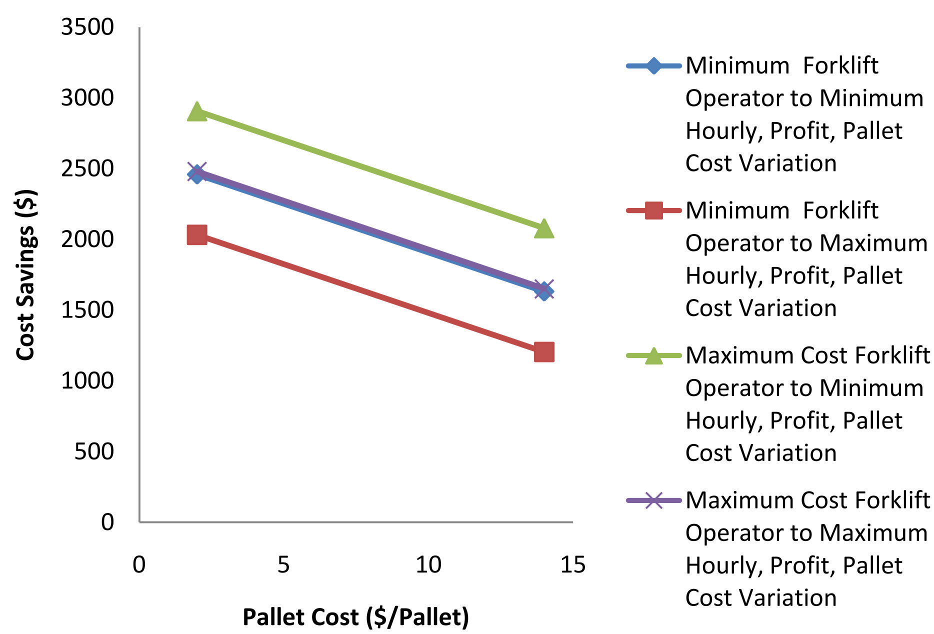

Figure 5-27 Pallet Cost Influence Forklift Operator to Hourly Labor Cost #2

5.12 Model Validation

The model was distributed to three industry professionals for validation. Feedback was obtained from presidents of a 3PL, a packaging firm, and a pallet company; all are affiliated with exports/imports. The president of the 3PL input imported product data into the model, and made assumptions for the data needed on the export end. According to his results, the model was accurate. Through discussion, it was found that the actual costs (loading labor, drayage, and loading on a ship) for products considered free on board may be difficult to obtain (President 3PL, personal communication, 2009).

The other professionals also evaluated the model. According to the president of the pallet company, the research will be beneficial to pallet manufacturers (President Pallet Company, personal communication, 2009). The president of the packaging company indicated that floor loading is utilized due to the cost of shipping and pallets. It was stated that given the scope of the research, it provides a basis for future research. Future recommendations to enhance the research were to consider the associated costs of mold/mildew on pallets, the cost of disposing of pallets, and safety issues that occur by using low quality pallets. It was stated that the research was appreciated (President Packaging Company, personal communication, 2009).

CHAPTER 6. RESULTS AND DISCUSSION

6.1 Research Findings

Through this research, it was found that consumer grade boxed products were commonly floor loaded in containers to maximize the container capacity and obtain a higher container value. Shipping constitutes the highest cost in the export/import supply chain. By maximizing the container capacity fewer containers are needed, which results in an initial lowered shipping price per product. Pallets add weight, occupy space, and can potentially restrict container capacity. However, field studies and questionnaires conducted in this study revealed that floor loading required more time to load and unload containers, which resulted in higher labor costs and restricted product throughput. In order to make a defined decision of how boxed products should be loaded in containers, the overall efficiency (cost and time) meeting daily demand was considered. Variables that influence the decision were identified in chapter four. By incorporating the variables into a model, a method to make an efficient decision to either floor load boxes or unitize boxes on pallets in containers was obtained. The model compares the overall costs and time for the two loading methods.

6.2 Evaluating Efficiency

6.2.1 Cost

Many of the common theories about the decision to import boxes floor loaded did not consistently reveal a cost savings benefit. For example, obtaining more boxes per container floor loaded did not guarantee a cost savings benefit. More boxes per container did result a higher container value, but considering boxes needed per day, the product values were equal for the two loading methods. To demonstrate the application of the model, several scenarios involving various products were considered. The model was demonstrated by comparing the labor costs and customer charge for the two loading methods.

Through this research, three types of labor (lumper, hourly manually unloading boxes, and a forklift operator) were identified. Forklift operators were found to be the most cost efficient labor. Lumper services were found to be more cost efficient than hourly manual labor when a customer charge was applied. Due to the low labor costs of forklift operators, a cost savings benefit was observed in many of the applied scenarios, even though an excess container was needed to meet demand. The cost of shipping an excess container can impact the cost benefit. A full or partial shipping/drayage charge is applied to excess containers. The container volume occupied by boxes or pallets and boxes has an influence on the overall cost. An assumption made to demonstrate the model was that demand could be met in one floor loaded container. For excess containers charged full shipping/drayage, a cost savings benefit is unlikely when demand is met in one floor loaded container. However, depending on the magnitude of the cost savings and the number of containers needed per day, a cost savings benefit is possible for boxes unitized on pallets, even when excess containers are charged in full.

6.2.2 Time

Using the provided unload times from data collection, it was determined that fewer receiving dock doors are needed to meet daily demand if boxes arrive unitized on pallets, even though more containers may be needed. For fast moving products, or for facilities that receive an array of products from different locations, the goal may be to receive and unload as many containers as possible in a work day. In one example, the model showed that the option exists to unload 13.55 containers from one receiving dock door when boxes were unitized on pallets, compared to only 3.55 containers per door when boxes are floor loaded.

6.3 Research Summary

In order to make an efficient decision of how to load boxed products in a container, both costs and time need to be considered. The overall efficiency of the container is influenced by how the contents are loaded. The decision to distribute product floor loaded or unitized needs to be made on a SKU basis. The developed model is a tool to assist in making an efficient decision. It provides the associated costs of shipping and handling throughout the supply chain and determines which loading method is overall most efficient.

A cost savings benefit for boxes unitized on pallets occurs because the low labor cost of a forklift operator has offset the high labor cost associated with floor loading. Additionally, the low labor cost of a forklift operator offsets the cost of an excess container required to meet demand. Floor loading is more cost efficient when the total cost is less than the total cost of unitizing boxes on pallets. The pallet cost and number of pallets allowable per container have an influence on the cost benefit. For the model, the container was maximized. Limitations due to warehouse racks or customer pallet specifications would influence the magnitude of the cost savings, especially if de-palletizing and re-palletizing is required.

IDC and 3PL efficiency should be considered in the overall determination to distribute boxes floor loaded or unitized on pallets to ensure demand can be met. Through this research it was found that current supply chains are nearing capacity as container shipment volumes have historically increased at overwhelming rates. Floor loading may become less desirable, as IDCs and 3PLs may no longer have the option of parking a container at a dock door for an extended period of time to unload. An increase in demand results additional labor and increased costs to customers. Labor costs and dock door restrictions can be offset by receiving boxes unitized on pallets.

CHAPTER 7. CONCLUSIONS

Intercontinental trade expanded rapidly with the development and utilization of the ocean freight container. Freight containers provide efficient access to global raw materials and inexpensive manufacturing and labor costs. Ocean freight containers are the most cost efficient method of distributing boxed products over long distances. The overall efficiency of containers is influenced by how boxed products are loaded within. Overall, under current circumstances, when additional containers are needed to meet demand for boxes unitized on pallets, floor loading is likely to be more efficient. However, fluctuations in shipping and transport costs, labor costs, pallet costs, and the state of the economy all have an impact on which loading method is most efficient.

The conclusions to this research were developed by meeting the three proposed research objectives.

7.1 Intercontinental container cargo loading methods for boxed products

- Most boxed consumer goods are imported floor loaded, not unitized on pallets, to maximize the allowable container capacity. This results in an increased container value.
- Beverages and furniture, in boxes, were found to be imported on pallets.
- Heavy products such as beverages and furniture would weigh the container out before cubing it out, and therefore the use of pallets would not affect container capacity.
- Most industrial products are imported on pallets.
- Currently, the overall export/import supply chain efficiency is not considered when making decisions to either floor load or unitize boxes on pallets.

7.2 <u>The relative efficiency of container cargo loading methods for boxed products</u>

- There are three types of labor involved with loading and unloading shipping containers. 1) Lumper (paid based on the number of containers unloaded) manually unloading floor loaded containers, 2) hourly worker manually unloading floor loaded containers, and 3) hourly forklift operators unloading pallets from containers.
- The use of a forklift and pallets is the most efficient type of labor and significantly reduces the unloading labor cost when compatibility exists between the boxed product and pallet and the pallet and material handling equipment.
- Hourly labor unloading floor loaded product was the second most cost efficient method when no customer charge was applied.
- When applying a customer charge, hourly manual labor was the least cost efficient.
- Utilizing forklifts provided the most efficient unloading times.
- The maximum time needed using the forklift equaled the minimum time needed for floor loaded boxes.
- Due to efficient unloading times, fewer dock doors are needed to unload boxes palletized in containers when using forklift handling.

7.3 <u>A decision methodology to compare the overall efficiency of loading methods of boxed products floor loaded and boxed products unitized on pallets</u>

- A sequence of calculations was developed for boxes imported floor loaded and unitized.
- Boundaries for the decision methodology were obtained through field studies at three IDC and three 3PL warehouse facilities.
- Observations at these facilities provided information regarding the loading and unloading of containers, about product characteristics, associated costs, and facility capacity.

Interviews and relevant documentation were beneficial to the development of the decision methodology.

- The model was validated by three industry professionals.
- The analysis provides a breakdown of costs throughout the export/import supply chain for the two loading methods. These costs are subtracted from the product value meeting demand, which provides net values for floor loaded boxes and boxes unitized on pallets meeting demand.
- Comparing the net value of floor loaded boxes to boxes in unitized form results in a cost benefit for either boxes floor loaded or boxes unitized on pallets.
- Using time inputs, the number of receiving dock doors needed to unload containers and maximize throughput were obtained.

7.4 Shipping

- Shipping constitutes the highest cost in the export/import supply chain.
- It is commonly perceived that maximizing the capacity of the container to reduce the amount of container shipments needed to meet demand is the best solution.
- It was demonstrated that the cost savings of shipping fewer containers can be offset by other costs incurred throughout the export/import supply chain.
- A sensitivity analysis revealed that labor cost, pallet cost, and the variation in box count between loading methods were strong indicators of whether or not the cost savings benefit exists for boxes floor loaded or boxes unitized on pallets.

7.5 Equal Box Count Variation

- Palletize, when comparing a lumper service to forklift operator when no charge to the customer is applied (assuming all other variables are constant).
- Comparing hourly to forklift operator labor, and no charge to the customer, most scenarios should be palletized. Floor load when considering minimum hourly to maximum forklift operator labor (assuming all other variables are constant and adequate dock doors are available).
- For both manual labor types, when a profit is charged, most scenarios result a cost savings by palletizing. Boxes should be floor loaded when a minimum manual labor plus profit and maximum forklift operator labor plus profit are considered (assuming all other variables are constant and adequate dock doors are available).

7.6 Minimal Box Count Variation

- Floor load when comparing a lumper service to forklift operator labor when no charge to the customer is applied. When considering a profit, most scenarios result a cost savings by floor loading. Palletize when comparing maximum lumper plus profit to minimum forklift operator labor plus profit (assuming all other variables are constant, a partial charge is applied to the excess container, and adequate dock doors are available).
- Floor load when comparing hourly to forklift operator labor when no charge to the customer is applied. When considering a profit, most scenarios result a cost savings by floor loading. Palletize when comparing maximum hourly plus profit to minimum forklift operator labor plus profit or maximum hourly plus profit to maximum forklift

operator, plus profit (assuming all other variables are constant, a partial charge is applied to the excess container, and adequate dock doors are available).

7.7 Large Box Count Variation

- Floor loading is more effective when comparing lumper or hourly to forklift operator labor considering either charge to customer or no charge to customer (assuming all other variables are constant and adequate dock doors are available).

7.8 Pallets

- The cost of pallets can be influential in determining which loading method is most cost efficient when an equal or minimal box count variation exists between the two loading methods per container.
- Export wooden pallets may be more expensive than domestic pallets, due to the treatment cost.
- The fewer containers needed per day and fewer pallets per container, the less impact of the additional pallet cost. As the number of containers and pallets per container increases, the difference in pallet cost becomes more influential.
- As a large variation in box count occurs between the two loading methods per container, more containers are needed to meet demand compared to minimum box count variation for boxes unitized on pallets. Labor and pallet costs become less influential as the variation in box count increases.

7.9 Research Contributions

The model will assist manufacturers, shippers, buyers, and receivers of boxed products make a more informed decision in regard to the most efficient container loading and unloading procedures. The model:

- Determines which loading method minimizes shipping and handling costs while meeting demand.
- Determines which loading method minimizes shipping and handling costs while maximizing throughput.
- Determines the number of receiving dock doors needed to meet demand and maximize throughput.
- Predicts the impact of pallet use on the total export/import supply chain cost.
- Accommodates exports/imports; however, the model could easily be adapted for domestic use, since floor loading is utilized domestically in trailers.

7.10 Future Research

This research focused specifically on export/import operations. Expansion of the model to incorporate an “overall” benefit of distributing boxes floor loaded or in unitized form from point of manufacture to point of purchase is feasible. Pre and post loading operations will need to be considered, which would include:

- The costs initiated by truck drivers moving containers from receiving dock doors to accommodate other containers
- Pallet repair and disposal costs
- The cost to return or dispose of damaged products for the two loading methods

The model assumed that pallets were of equal quality for both exporters and importers. However, this was found not to be the case. Future studies could:

- Determine if pallet quality does affect loading and unloading times. If so, what minimum quality levels are needed?
- Determine methods of supplying the required pallet quality.

On an IDC, 3PL level, most facilities have access to forklifts. Research could be conducted to:

- Determine the effect of palletization on the return on investment of idle forklift equipment as an additional cost savings of unitizing in containers.

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Appendix 1 IRB Approval Form

Virginia Tech

Office of Research Compliance
Carmen T. Green, IRB Administrator
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24061
540/231-4358 Fax 540/231-0959
e-mail ctgreen@vt.edu
www.irb.vt.edu
FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: February 20, 2009

MEMORANDUM

TO: Robert L. Smith
Alexander Hagedorn

FROM: Carmen Green

SUBJECT: **IRB Exempt Approval:** "The Effect of Unitization on the Efficacy of Intercontinental Product Movement Using Freight Containers" , IRB # 09-096

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of February 20, 2009.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

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Appendix 2 Recruiting Script

Hello,

I am a PhD student at Virginia Tech working on a dissertation titled *"The Effect of Unitization on the Efficiency of Intercontinental Product Movement Using Freight Containers.*" I have developed an online survey to assist with collecting data. Please note, the survey isn't concerned with names of any sort (**names of warehouse, distribution centers, people, and products are irrelevant to the study, and will not be requested)**. Data provided will not be traceable to your company. Below is a description of the survey, as well as a link to access it. The questions are brief and will not take long to complete.

About the survey

- It is often unclear whether imported products should be palletized or floor loaded. There are pros and cons to each scenario. This survey focuses on direct imports into the U.S.A. and was designed to gather information about both palletized and floor loaded imports.

- Data collected involving unloading ocean freight containers will be most relevant to the study.

- Data collected through this survey will assist in the development of a model to predict the most economical and efficient means of importing product, based upon product attributes and the warehouse/distribution center capabilities.

- Once complete, this model should be a helpful tool for industry.

Directions on taking the survey

- The survey is available at: https://survey.vt.edu/survey/entry.jsp?id=1233808487628

- Click on the above link, it takes a few seconds to load

NOTE: If link doesn't work by clicking on it, please copy and paste it into the address bar

- If you receive this survey and are not affiliated with unloading ocean freight containers, please distribute to appropriate individuals in your supply chain that are affiliated with unloading ocean freight containers.

- Please answer all questions that pertain. If a question doesn't pertain, or you don't feel comfortable answering, please provide a N/A in the blank. For any response termed "other," please provide additional information.

- At the end of the survey, your email address will be requested, in case further assistance is needed. Emails will only be used for this purpose, if you don't want to provide an email, please leave it blank.

REMEMBER TO SUBMIT YOUR ANSWERS.
The submit button is at the end of the survey

Thank you for your consideration to take or pass on this voluntary survey,
I really appreciate it,

Thanks Again,
Alexander J. Hagedorn

If you have any questions about the survey, please contact me.

Alexander J. Hagedorn
PhD Candidate/Packaging Science
Virginia Tech
Department of Wood Science and Forest Products
Phone 540-231-7135
Email, ahagedor@vt.edu

Appendix 3 Questionnaire

U.S.A. Warehouse Import Data

1). Where is your import distribution center located? Please provide the state or state abbreviation.

DC Location

2). What is the highest volume, continuous product sector (Examples: ceiling fans, tires, canned goods...) arriving at your facility to be unloaded from an ocean container? The specified product identified will be referred to throughout the survey.

Top product sector

3). How would you classify the specified product?

- Consumer Grade Product
- Industrial Grade Product
- other:

4). Where is the specified product coming from?

- China
- Germany
- Japan
- Korea
- United Kingdom
- other:

5). How long (in weeks) does it take to get the specified product from its point of origin to your facility?

Duration in weeks

6). Who is responsible for paying the shipping/drayage charges to get the specified product to the U.S.A.?

- This facility
- The product Manufacturer
- The buyer
- other:

7). What is the charge ($) of shipping and drayage to get the specified product to your facility (per container)? Please label and separate answers.

8). Which sea port does the specified product arrive?

Port of product entry

9). On average, how many containers of this specified product arrive at your facility to be unloaded daily? If more convenient, specify per week, per month, or per year.

# of containers with specified product

10). Primarily, what size ocean container is used to import this specified product?

- 20 foot Standard
- 40 foot Standard
- 20 foot High Cube
- 40 foot High Cube
- other:

11). What are the attributes of the specified product?

- Fragile
- Chemical
- Perishable

other:

12). Classify the specified product

- Carton
- Bag
- Roll (steel, paper)
- other:

13). If you chose carton for the above question, specify the quantity of products per carton.

- 1
- 2
- 3
- 4
- 5
- 6
- other:

14). If specified product arrives in a carton, please specify the size of the shipping carton (length, width, and height) for the specified product (in inches).

Carton size

15). What is the weight of the specified product (in pounds)? If specified product is in a carton, please specify total carton weight.

Product/packaging weight

16). What is the value of the specified product (in US $)? If specified product is in a carton, please specify total carton value.

Product value

17). What is the total number of specified products on an inbound container? (Example 1200 cartons…)

products per container

18). How many SKUs of the specified product arrive per container?

- 1
- 2
- 3
- 4
- 5
- 6
- other:

19). If multiple SKUs exist, is the product/packaging size similar to others in the container?

- Yes
- No
- other:

20). Is the specified product the only product upon arrival per container or are other product sectors present per container upon arrival (mixed container load)? (Example ceiling fans and tires)

- One product sector per container
- Mixed Container

21). Are specified products palletized in the container upon arrival?

- Yes
- No

22). If palletized in the container upon arrival, what is the size of the pallet carrying the specified product? If specified product is not palletized in the container upon arrival skip this question.

- ( ) 1200 X 1000mm (47.24 x 39.37 inches)
- ( ) 1100 X 1100mm (43.30 x 43.30 inches)
- ( ) 1200 X 800mm (47.24 x 31.50 inches)
- ( ) 48 X 40 inches
- ( ) It varies from shipment to shipment
- (•) other: __________

23). If specified product is palletized in the container upon arrival, how many products per pallet? If specified product arrives in a carton, specify cartons per pallet. If specified product sector is not palletized in the container upon arrival, skip this question.

Quantity per pallet __________

24). If specified product is palletized in the container upon arrival, how many pallets per full container? If specified product is not palletized in the container upon arrival, skip this question.

Pallets per container __________

25). As the specified product is being unloaded...

- ( ) Floor loaded product is placed on a pallet then sent to storage
- ( ) Floor loaded product is placed on a pallet then loaded into an outbound trailer
- ( ) Floor loaded product is loaded into an outbound trailer floor loaded
- ( ) Palletized product in the container is loaded into an outbound trailer floor loaded
- ( ) Palletized product in the container is loaded into an outbound trailer on same pallet as arrival
- ( ) Palletized product in the container is depalletized and repalletized on another pallet then loaded
- ( ) Palletized product in the container is depalletized and repalletized on another pallet then stored
- ( ) Palletized product in the container is stored in the warehouse on the imported pallet
- (•) other: __________

26). If applicable, in regard to the above question, why is the specified product depalletized and repalletized? What size pallet is used (your facility's pallet) and why? How much time and labor is needed to accomplish this? What happens to original pallet? If not applicable, skip this question.

____

27). Who or what dictates whether the specified product should be palletized or floor loaded in the container upon arrival?

28). How many receiving dock doors does your facility have?

#dock doors

29). How long does it take to unload a container of this specified product, please specify minutes or hours?

#of minutes or hours to unload

30). Primarily, how is the specified product unloaded?

- Forklift
- Pallet Jack
- Manual labor loading product onto pallets
- other:

31). How many people are involved with the unloading process for one container of the specified product?

- 1
- 2
- 3
- 4
- 5
- other:

32). What is the status of your employees unloading containers of the specified product?

- Full time (paid hourly)
- Temporary or Lumper service (paid by the container)
- other:

33). What is the average wage paid to one employee to unload one container of the specified product (include benefits if applicable)? If easier, indicate hourly wage. If lumper service is used, please provide amount paid per container.

wage$

34). What is the cost to your customer to unload a container of the specified product?

Cost to customer

35). On average, how many specified products are damaged upon arrival per container?

damaged

36). Once specified products are unloaded, how long are the specified products stored at this facility before being shipped out?

Storage duration

37). How does the specified product leave your facility?

- Palletized (same pallet, same product count as arrival)
- Floor loaded
- Order Picked with other products and sent out palletized
- other:

38). How would you classify your facility?

- Warehouse/distribution center at or near capacity
- Warehouse/distribution center not at capacity
- other:

39). If demand for the specified product increased significantly, what would your facility change in order to get the product in and out of your facility quicker?

40). If labor rates for personnel unloading containers of specified product were to increase, what measures would your facility change?

Please provide your email address in case more information is requested or clarification of existing questions is needed. It will only be used for this purpose. If you do not want to provide it, please leave it blank. Again, Thank You, your time and input is appreciated! REMEMBER TO SUBMIT!

Email

Appendix 4 Definitions in the Model

- ***Boxes:*** Boxes are commonly referred to as cartons. A carton is defined as "a rectangular box weighing between 5 and 50 pounds, handled by one person, conveyable, and can be stored on a pallet" (Bartholdi and Hackman, 2007, p. 71). TOPS uses the terms carton and shipper (TOPS). Packaging terminology classifies a carton as paperboard construction that "can easily be held in one hand" (Hanlon, Kelsey, & Forcinio, 1998, p. 153). For the purpose of this research, the term boxes will be used and is intended to include paperboard cartons and corrugated fiberboard boxes used for distribution of products in ocean freight containers.
- ***Boxes per Container:*** The number of boxes per container can be obtained by entering the dimensions (length, width, and height) into TOPS or similar software program. The software provides the maximum number of boxes that will fit in a container either floor loaded or unitized on pallets.
- ***Box/Container Weight:*** Box and container weight can be obtained by entering the box weight (net and gross) and allowable container weight into TOPS or similar software. Based upon inputs, the software provides container weight. If pallets are used in the container, the weight of the pallet is also required. Container size selection modifications may need to be made to satisfy weight restrictions or demand of the boxed products.
- ***Containers to Meet Daily Demand:*** Containers to meet daily demand is derived from the number boxes in a container floor loaded or unitized on pallets and the number of boxes needed per day. Mixed SKUs use volume to determine container demand.
- ***Drayage Cost:*** Drayage cost is the cost to move a container to a port (export drayage) and from a port to an IDC or 3PL facility (import drayage). For the model, no additional

charges (fuel surcharge and overweight permits) are considered. If a fuel surcharge is incurred in addition to the base drayage cost, the costs are summed to obtain the drayage cost. If an overweight permit is necessary, it is included in the summation.

- ***Shipping Cost:*** Shipping cost refers to a lump sum cost (shipping and port charges) for loading the container on a ship, transferring the container overseas, and offloading the container onto a chassis. When a lump sum rate is not used, the charges are separate. For this case, sum the costs to equal shipping costs.
- ***Shipping and Handling Costs:*** Shipping and handling costs include: the cost of labor to floor load boxes into containers or the cost to load unitized boxes on pallets in containers, export pallet cost (if applicable), pallet phytosanitation cost (referred to in the model as treatment cost) (if applicable), drayage cost to port (see drayage cost), shipping cost (see shipping cost), drayage to import distribution center (see drayage cost), labor cost to unload floor loaded boxes or boxes unitized on pallets, and the import pallet cost (if applicable).
- ***SKU (Stock Keeping Unit) (Single SKU):*** A single SKU container consists of the same products with the same box dimensions/weights, or different products with the same box dimensions/weights.
- ***SKU (Stock Keeping Unit) (Mixed SKU):*** A mixed SKU container consists of different products with different box dimensions/weights, or same products with different box dimensions/weights.
- ***Value:*** Value is defined as "a measure of the worth that a person ascribes to a good or service" (Thuesen & Fabrycky, 2001, p. 15). For the model, either base value (the worth of just the product), or value including product and profit can be used. Value is used for

individual boxes, individual containers (floor loaded or palletized), and for containers needed to meet daily demand.

- ***Value (Net):*** Net value is the remaining boxed product value after shipping and handling costs are removed for boxes floor loaded and boxes unitized on pallets.
- ***Value (Net Delta):*** Net value delta is the difference between the net value for floor loaded boxes and the net value for boxes unitized on pallets.

Appendix 5 Equal Box Count

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	***-$135.00***	***-$213.75***	***-$325.00***
Average Forklift Operator	$2.43	***-$76.32***	***-$187.57***
Maximum Forklift Operator	$140.00	$61.25	***-$50.00***
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	***-$73.46***	***-$85.06***	***-$105.46***
Average Forklift Operator	**-$63.74**	**-$75.34**	**-$95.74**
Maximum Forklift Operator	**-$48.00**	**-$59.60**	**-$80.00**
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	***-$310.00***	***-$467.50***	***-$690.00***
Average Forklift Operator	***-$35.14***	***-$192.64***	***-$415.14***
Maximum Forklift Operator	$240.00	$82.50	***-$140.00***
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	***-$186.92***	***-$210.12***	***-$250.92***
Average Forklift Operator	**-$167.48**	***-$190.68***	***-$231.48***
Maximum Forklift Operator	**-$136.00**	**-$159.20**	***-$200.00***
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	***-$247.00***	***-$395.50***	***-$675.00***
Average Forklift Operator	***-$109.57***	***-$258.07***	***-$537.57***
Maximum Forklift Operator	$28.00	***-$120.50***	***-$400.00***
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	***-$9.46***	***-$34.21***	***-$87.46***
Average Forklift Operator	$0.26	**-$24.49**	**-$77.74**
Maximum Forklift Operator	$16.00	**-$8.75**	**-$62.00**
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	***-$534.00***	***-$831.00***	***-$1,390.00***
Average Forklift Operator	***-$259.14***	***-$556.14***	***-$1,115.14***
Maximum Forklift Operator	$16.00	***-$281.00***	***-$840.00***
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	***-$58.92***	***-$108.42***	***-$214.92***
Average Forklift Operator	**-$39.48**	**-$88.98**	**-$195.48**
Maximum Forklift Operator	**-$8.00**	**-$57.50**	**-$164.00**

Appendix 6 Minimal Variation

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	$165.68	$86.93	***-$24.32***
Average Forklift Operator	$312.93	$234.18	$122.93
Maximum Forklift Operator	$460.32	$381.57	$270.32
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$225.76	$214.16	$193.76
Average Forklift Operator	$236.17	$224.57	$204.17
Maximum Forklift Operator	$253.04	$241.44	$221.04
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	***-$7.86***	***-$165.36***	***-$387.86***
Average Forklift Operator	$286.64	$129.14	***-$93.36***
Maximum Forklift Operator	$581.43	$423.93	$201.43
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$112.30	$89.10	$48.30
Average Forklift Operator	$133.13	$109.93	$69.13
Maximum Forklift Operator	$166.86	$143.66	$102.86
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$53.68	***-$94.82***	***-$374.32***
Average Forklift Operator	$200.93	$52.43	***-$227.07***
Maximum Forklift Operator	$348.32	$199.82	***-$79.68***
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$289.76	$265.01	$211.76
Average Forklift Operator	$300.17	$275.42	$222.17
Maximum Forklift Operator	$317.04	$292.29	$239.04
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	***-$231.86***	***-$528.86***	***-$1,087.86***
Average Forklift Operator	$62.64	***-$234.36***	***-$793.36***
Maximum Forklift Operator	$357.43	$60.43	***-$498.57***
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$240.30	$190.80	$84.30
Average Forklift Operator	$261.13	$211.63	$105.13
Maximum Forklift Operator	$294.86	$245.36	$138.86

Appendix 7 Medium Variation

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	$51.90	**-$26.85**	**-$138.10**
Average Forklift Operator	$195.05	$116.30	$5.05
Maximum Forklift Operator	$338.36	$259.61	$148.36
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$112.58	$100.98	$80.58
Average Forklift Operator	$128.79	$117.19	$96.79
Maximum Forklift Operator	$207.86	$196.26	$175.86
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	**-$122.25**	**-$279.75**	**-$502.25**
Average Forklift Operator	$164.06	$6.56	**-$215.94**
Maximum Forklift Operator	$450.67	$293.17	$70.67
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	**-$0.88**	**-$24.08**	**-$64.88**
Average Forklift Operator	$31.54	$8.34	**-$32.46**
Maximum Forklift Operator	$189.67	$166.47	$125.67
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	**-$60.10**	**-$208.60**	**-$488.10**
Average Forklift Operator	$83.05	**-$65.45**	**-$344.95**
Maximum Forklift Operator	$226.36	$77.86	**-$201.64**
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$176.58	$151.83	$98.58
Average Forklift Operator	$192.79	$168.04	$114.79
Maximum Forklift Operator	$271.86	$247.11	$193.86
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	**-$346.25**	**-$643.25**	**-$1,202.25**
Average Forklift Operator	**-$208.44**	**-$643.25**	**-$915.94**
Maximum Forklift Operator	$78.17	**-$70.33**	**-$629.33**
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$127.12	$77.62	**-$28.88**
Average Forklift Operator	$159.54	$110.04	$3.54
Maximum Forklift Operator	$317.67	$268.17	$161.67

Appendix 8 Large Variation

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	$2,156.76	$2,078.01	$1,966.76
Average Forklift Operator	$2,380.36	$2,301.61	$2,190.36
Maximum Forklift Operator	$2,604.18	$2,525.43	$2,414.18
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$2,205.47	$2,193.87	$2,173.47
Average Forklift Operator	$2,230.79	$2,219.19	$2,198.79
Maximum Forklift Operator	$2,354.28	$2,342.68	$2,322.28
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$1,994.59	$1,837.09	$1,614.59
Average Forklift Operator	$2,441.78	$2,284.28	$2,061.78
Maximum Forklift Operator	$2,889.43	$2,731.93	$2,509.43
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$2,092.01	$2,068.81	$2,028.01
Average Forklift Operator	$2,142.64	$2,119.44	$2,078.64
Maximum Forklift Operator	$2,389.62	$2,366.42	$2,325.62
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$2,044.76	$1,896.26	$1,616.76
Average Forklift Operator	$2,268.36	$2,119.86	$1,840.36
Maximum Forklift Operator	$2,492.18	$2,343.68	$2,064.18
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$2,269.47	$2,244.72	$2,191.47
Average Forklift Operator	$2,294.79	$2,270.04	$2,216.79
Maximum Forklift Operator	$2,418.28	$2,393.53	$2,340.28
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$1,770.59	$1,473.59	$914.59
Average Forklift Operator	$2,217.78	$1,920.78	$1,361.78
Maximum Forklift Operator	$2,665.43	$2,368.43	$1,809.43
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$2,220.01	$2,170.51	$2,064.01
Average Forklift Operator	$2,270.64	$2,221.14	$2,114.64
Maximum Forklift Operator	$2,517.62	$2,468.12	$2,361.62

Appendix 9 Mixed SKU 1

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	$779.20	$761.20	$735.77
Average Forklift Operator	$865.81	$847.81	$822.37
Maximum Forklift Operator	$952.51	$934.50	$909.07
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$785.06	$782.41	$777.74
Average Forklift Operator	$791.18	$788.53	$783.87
Maximum Forklift Operator	$801.10	$798.45	$793.79
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$747.41	$711.40	$660.54
Average Forklift Operator	$920.63	$884.62	$833.75
Maximum Forklift Operator	$1,094.02	$1,058.01	$1,007.15
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$759.12	$753.81	$742.30
Average Forklift Operator	$771.37	$766.07	$756.74
Maximum Forklift Operator	$791.21	$785.90	$776.58
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$753.60	$719.65	$655.75
Average Forklift Operator	$840.21	$806.26	$742.36
Maximum Forklift Operator	$926.90	$892.95	$829.05
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$799.69	$794.03	$781.86
Average Forklift Operator	$805.81	$800.16	$787.98
Maximum Forklift Operator	$815.73	$810.08	$797.90
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$696.20	$628.30	$500.50
Average Forklift Operator	$869.42	$801.52	$673.72
Maximum Forklift Operator	$1,042.81	$974.91	$847.11
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$788.38	$777.06	$752.72
Average Forklift Operator	$800.63	$789.32	$764.97
Maximum Forklift Operator	$820.47	$809.15	$784.81

Appendix 10 Mixed SKU 2

Equal Cost Export Labor, Charge to Customer	Minimum Lumper FL	Average Lumper FL	Maximum Lumper FL
Minimum Forklift Operator	$1,313.94	$1,293.54	$1,264.72
Average Forklift Operator	$1,410.84	$1,390.44	$1,361.61
Maximum Forklift Operator	$1,507.84	$1,487.43	$1,458.61
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$1,320.77	$1,317.76	$1,312.47
Average Forklift Operator	$1,327.62	$1,324.61	$1,319.33
Maximum Forklift Operator	$1,338.72	$1,335.71	$1,330.43
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$1,277.73	$1,236.92	$1,179.27
Average Forklift Operator	$1,471.52	$1,430.71	$1,373.06
Maximum Forklift Operator	$1,665.51	$1,624.70	$1,567.05
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$1,291.37	$1,283.47	$1,274.79
Average Forklift Operator	$1,305.07	$1,299.06	$1,288.49
Maximum Forklift Operator	$1,327.27	$1,321.26	$1,310.69
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$1,284.93	$1,246.45	$1,174.03
Average Forklift Operator	$1,381.82	$1,343.34	$1,270.93
Maximum Forklift Operator	$1,478.82	$1,440.34	$1,367.92
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$1,337.35	$1,330.94	$1,317.14
Average Forklift Operator	$1,344.20	$1,337.79	$1,323.99
Maximum Forklift Operator	$1,355.30	$1,348.89	$1,335.09
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$1,219.69	$1,142.73	$997.90
Average Forklift Operator	$1,413.48	$1,336.53	$1,191.69
Maximum Forklift Operator	$1,607.47	$1,530.51	$1,385.68
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$1,324.53	$1,311.71	$1,284.11
Average Forklift Operator	$1,338.24	$1,325.41	$1,297.82
Maximum Forklift Operator	$1,360.43	$1,347.61	$1,320.01

Appendix 11 Mixed SKU 3

Equal Cost Export Labor, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$19.82	**-$20.53**	**-$77.52**
Average Forklift Operator	$57.01	$16.67	**-$40.33**
Maximum Forklift Operator	$94.24	$53.89	**-$3.10**
Equal Cost Export Labor, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	$56.29	$50.34	$39.89
Average Forklift Operator	$58.92	$52.97	$42.52
Maximum Forklift Operator	$63.18	$57.23	$46.78
Variable Export Labor Cost, Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	**-$74.78**	**-$155.46**	**-$269.44**
Average Forklift Operator	**-$0.40**	**-$81.08**	**-$195.06**
Maximum Forklift Operator	$74.06	**-$6.62**	**-$120.60**
Variable Export Labor Cost, No Charge to Customer	**Minimum Lumper FL**	**Average Lumper FL**	**Maximum Lumper FL**
Minimum Forklift Operator	**-$1.84**	**-$13.72**	**-$34.62**
Average Forklift Operator	$3.42	**-$8.46**	**-$29.36**
Maximum Forklift Operator	$11.94	$0.06	**-$20.84**
Equal Cost Export Labor, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	**-$37.56**	**-$113.63**	**-$256.81**
Average Forklift Operator	**-$0.37**	**-$76.44**	**-$219.62**
Maximum Forklift Operator	$36.86	**-$39.21**	**-$182.39**
Equal Cost Export Labor, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$89.07	$76.39	$49.11
Average Forklift Operator	$91.70	$79.02	$51.75
Maximum Forklift Operator	$95.96	$83.28	$56.00
Variable Export Labor Cost, Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	**-$189.53**	**-$341.67**	**-$628.04**
Average Forklift Operator	**-$115.15**	**-$267.29**	**-$553.66**
Maximum Forklift Operator	**-$40.69**	**-$192.84**	**-$479.20**
Variable Export Labor Cost, No Charge to Customer	**Minimum Hourly FL**	**Average Hourly FL**	**Maximum Hourly FL**
Minimum Forklift Operator	$63.74	$38.38	**-$16.18**
Average Forklift Operator	$69.00	$43.64	**-$10.92**
Maximum Forklift Operator	$77.51	$52.16	**-$2.40**