EMPIRICAL ESTIMATION OF ATTRIBUTES INFLUENCING WAREHOUSE/DISTRIBUTION CENTER OPERATIONS: AN IN-DEPTH ANALYSIS OF THE WASHINGTON WAREHOUSE INDUSTRY

By

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Chair

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Abstract

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According to a recent Strategic Freight Transportation Analysis report, an estimated 21.6 million truck trips are made each year on Washington state highways. An estimated 45% of transported freight originated from or is destined for a warehouse or distribution center within the state. The growing amount of congestion within the state of Washington has prompted concern over the state's ability to anticipate and provide for current and future freight transportation infrastructure needs.

The general objective of this research is to investigate the operations and transportation usage of warehouse/distribution centers in Washington. Three specific objectives were outlined for this research. 1) Provide a description of the common operations and functions performed in the warehouse/distribution center industry and assess those characteristics associated with warehouses in Washington. 2) Determine the

relationship of warehouse size, and the number of inbound and outbound truckloads as variables in the warehouse/distribution center industry based upon warehouse functions in relation to facility location. Warehouses in the state of Washington are sorted into two regions, eastern and western. 3) Evaluate the same three issues in relation to warehouse functions and whether they are involved with international trade. Warehouses within the state were sorted into two warehouse types, international and domestic.

A multiple linear regression utilizing the stepwise procedure is performed in SAS to evaluate the relationships among warehouse size, and the number of inbound and outbound truckloads relative to warehouse functions. Upon analysis, public warehouses serve a critical role in the number of truckloads occurring within eastern Washington. Meanwhile, cold storage and ‘Other’ warehouse facilities generate a large number of truckloads in western Washington. Warehouses in eastern Washington operating a private fleet are typically smaller, while western warehouses outsourcing to third-party providers are larger.

A noticeable increase occurs in the number of truckloads for domestic warehouses which offer cross-docking services and handle a greater number of products. For international warehouses, cold storage facilities have significantly more truckload movement than other facilities types. The size of both domestic and international warehouses is significantly influenced by the number of bays and number of employees within a facility.

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INTRODUCTION

Problem Statement

The growing amount of congestion within the state of Washington has prompted concerns regarding the state's ability to appropriately anticipate and provide for current and future freight transportation infrastructure to improve freight mobility. According to a recent report by the Strategic Freight Transportation Analysis Program (SFTA), an estimated 21.6 million truck trips are made each year on state highways. Of that 21.6 million, an estimated 45% of transported freight originated from or is destined for a warehouse or distribution center within the state (Peterson, 2004).

In the United States, warehouse and distribution center operations have grown to become a $78 billion dollar industry (Hoffman, 2004). In the state of Washington alone, it is estimated that in October 2004 approximately 88,400 people were employed in the transportation and warehousing industry (Washington State Employment Security Department, 2004). This industry continues to grow as companies enhance their logistic capabilities and services to meet the increasing demands of the market. As this industry grows, freight volume and truck traffic increases.

In order to ensure efficient freight mobility, private and public policy makers will need to understand the complex operations and mode capabilities utilized within the warehouse/distribution center industry. To aid this understanding, an analysis of infrastructure development and investment within the state can be very useful.

Furthermore, an analysis is helpful in identifying which warehouse functions or characteristics influence truck movement within the state of Washington.

Purpose

As the warehouse/distribution center industry grows in Washington, it is important to identify the infrastructure development needed to maintain a viable, efficient distribution network. In addition, it is particularly critical to understand this industry's impact on future freight movement and facility development in Washington. The general scope of this research is to develop insights into the operations and freight mobility needs of the warehouse/distribution center industry. The analysis provided in this research will enhance any future modeling and planning efforts in both distribution and real estate development within Washington.

Research Objectives

The general objective of this research is to investigate the operations and transportation usage of warehouse/distribution centers in Washington. Three specific objectives were outlined for this research. 1) Provide a description of the common operations and functions performed in the warehouse/distribution center industry and assess those characteristics associated with warehouses in Washington. 2) Determine the relationship of warehouse size, and inbound and outbound truck movement as variables in the warehouse/distribution center industry based upon warehouse functions in relation to facility location. Warehouses in the state of Washington are sorted into two regions, eastern and western. 3) Evaluate the same three issues in relation to warehouse functions and whether they are involved with international trade. Warehouses within the state were sorted into two warehouse types, international and domestic. For objectives two and three, a multiple linear regression model utilizing the stepwise model selection procedure is performed in SAS to evaluate the relationships among three issues and warehouse functions.

The study utilizes data collected from a mail survey conducted of the Warehouse/Distribution Center industry in Washington during the summer of 2004. The sample used for this study was compiled from local, county, state, and federal agencies. Collected information was categorized by the Standard Industrial Classification (SIC) or North American Industry Classification System (NAICS) codes associated with industries that operate in the storage and distribution of freight.

Thesis Format

In Chapter 2, the operational characteristics associated with warehouse/ distribution centers in Washington and how these facilities utilize transportation is discussed. A literature review of warehouse models in relation to facility location, routing, and size conclude this chapter. Chapter 3 discusses the data and methodology of warehouse functions or characteristics chosen for analysis. Chapter 4 provides analysis of warehouse functions in relation to facility location and international trade. Chapter 5 finishes with a summary and conclusion of the research.

CHAPTER 2

WAREHOUSE/DISTRIBUTION CENTERS

Functions

Throughout history warehousing has played a vital role in the supply chain. In the early days, the primary function of warehousing was the general storage of goods at a facility. Over time, the role of warehousing evolved into a complicated union between inventory management and logistics. This evolution stems from businesses adjusting to the constant changes in customer needs while attempting to enhance competitiveness within the market place.

The three basic functions of a warehouse are receiving, storage, and shipping (Ackerman, 1989). In general, these functions can be further separated into five common categories: stockpiling, product mixing, consolidation, distribution, and customer satisfaction (Ackerman, 1997). Each of these functions performs a unique service or task that enhances the profit margins of warehouses while at the same time meeting the demands of the customer.

When a warehouse maintains inventory overflow generated from either the producer and/or retail segments it is performing the function of stockpiling. For instance, a majority of agricultural commodities such as fruit are harvested and stored in warehouses in preparation to meet the non-seasonal demand of that product. Warehouses also maintain inventory overflow in preparation for the holidays. For example, Christmas cards will usually arrive at the warehouse during the mid-summer months of June and

July (Coyle, 1976). Warehouses, often at the request of retailers, maintain large quantities to handle fluctuating demand in a market.

Oftentimes, a company will offer a variety of products which are produced at different plants. Product mixing is a function which allows customers to effectively order from multiple product lines at once. The warehouse/distribution center serves as a primary meeting point for these various products. This function also decreases the number of facility locations needed to fulfill the order.

Consolidation allows companies to take less-than-truckload and less-than-carload shipments coming into the facility and combine them into larger outgoing shipments. This function enables companies to efficiently move more freight at lower transportation costs. Consolidation also allows the warehouse to make fewer truck trips with more stops to numerous destinations. The fourth function, distribution, is then the opposite of consolidation.

The last function, customer service, is performed when the warehouse maintains inventory to satisfy customer demand. Maintaining a certain level of inventory may not be the lowest cost to either the warehouse or customer. However, one justification for the inventory is that if the warehouse is able to provide the desired goods in close proximity to the customer, then there is greater customer satisfaction, which can lead to future sales (Coyle, 1976).

Operations

There are typically six major activities associated with warehouse operations: receiving, transfer, handling, storage, packing, and expediting (Gunasekaran, 1999). Product is first received at the warehouse, where it is transferred to either a storage area or forwarded on to an expediting area. Handling of the product occurs at any time when the item is transferred throughout the facility. Storage is simply the stockpiling of a product in preparation of an order. Some products are stored longer than others. Therefore, to reduce operation costs, items with the highest turnover are placed closest to the shipping area (Gunasekaran, 1999). Packing is the process of arranging particular items in preparation for shipment. Once the ordered items are packed, they are transferred to the expediting area where they are loaded for shipment to the customer.

To assist in the daily process of warehouse operations, many companies utilize warehouse and transportation management systems. These systems allow companies to monitor the flow of inventory and truck movement at a facility. In addition, the concept of just-in-time (JIT) delivery along with new technology such as electronic data interchange (EDI) and radio frequency identification (RFID) enable companies to become more efficient in the overall movement and storage of products handled at the warehouse facility.

Warehouse operations, however, are no longer just about the movement and storage of goods. Companies are beginning to offer a wide variety of value-added services to their list of basic functions. Labeling, repackaging, ticketing, and reverse logistics are just some of the value-added services now being offered. In effect, “many facilities are beginning to resemble light manufacturing plants" (Harps, 2003). Boyce (1999) attributes this growing trend of offering value-added services to potential profit. By offering such services, warehouses are able to generate higher margins.

Trends

Overall the operations of the warehousing industry are rapidly changing. Warehousing is acquiring new roles and responsibilities as it becomes a more integral part of the supply chain. According to Arnold Maltz (1998), one primary driver for this change is the amount of attention that customers are now devoting to the supply chain. Customers have conveyed a need for those warehouse companies that can provide the knowledge and skills necessary to improve overall supply chain performance. In addition, customers are continually seeking supply chain flexibility. As a result, warehousing is called on to adjust in order to meet future customer expectations.

Maltz's research identifies four specific roles that have emerged as the warehouse industry has adapted to customers' needs. The first role is the ability of the warehouse provider to be flexible. As mentioned earlier, warehouses are often called on to perform a variety of new services for a company. Warehouses that are flexible in performing these services improve their customer service and competitiveness within the market.

The second role is for the warehouse to be a knowledge center in all aspects of the supply chain. As more and more companies outsource the logistics aspect of their business, there is a need for knowledgeable staff who can handle the various operational and tactical components of the supply chain. There is also the need for warehouses to be educators for their customers as new technology and methods are introduced into the industry.

The third emerging role pertains to supply chain coordination. As a result of the associations, expertise, and knowledge of the overall supply chain that warehouses offer, more customers are turning over the coordination of the supply chain. Warehouses are involved with a number of service providers who handle the inbound and outbound movement of goods within the supply chain. The warehouse can utilize its associations with these service providers to more effectively manage inventory while reducing transportation and operation costs.

The final emerging role of warehouses is the support of marketing. This role is subdivided further into three parts. The first involves the warehouse serving as an information conduit between the buyer and seller, where information pertaining to daily shipments provides the seller potential marketing material. The second part of marketing support is related to the value-added services that a warehouse offers. These services enable the warehouse to be a part of the seller's sales team by marketing its' capability of effectively handling and enhancing the product to the intended customer. Finally, the warehouse acts as part of the overall service offering, where customers are able to identify the type of service they will receive from the warehouse and/or third-party provider.

Types

In today's global supply chain there is a variety of facility types performing numerous roles in the distribution of goods. Facilities are generally classified under one of the five facility types: private, public, contract, distribution center/hub, or cold storage. Private warehouses are those operated by the owner of the goods stored within. A public warehouse is one that is operated by a warehouseman engaged in the business of storing goods for hire. Contract warehouses are a combination of both public and private warehouses. A distribution center is defined as a public warehouse that in addition to storage handles and distributes a client's goods to his customers. Cold storage facilities are public warehouses that provide storage, freezing, distribution and related services for perishable foods and other refrigerated items (Hrabowska, 2001).

Washington Warehouse/Distribution Center Industry

A significant amount of information on the basic characteristics and operational procedures of warehouse/distribution centers in Washington was captured in a survey questionnaire conducted by Strategic Freight Transportation Analysis (SFTA) for the Washington State and United States Departments of Transportation (WSDOT & USDOT) during the summer of 2004. The survey questionnaire and subsequent analysis were divided into four parts: Warehouse Operations, Inter-modal Systems, International Trade, and Other Transportation Related Issues.

In the study, a total of 973 mailers were sent to various warehouses and distribution centers in the state of Washington. A total of 142 companies, or about 16%, of companies who received questionnaires returned useable survey responses. These responses were broadly dispersed throughout the state.

The useable responses were sorted into six coverage areas based upon accessibility to key highways and their proximity to densely populated regions of the state. The number of survey respondents in each of the six sample coverage areas is indicated in Figure 1.1.

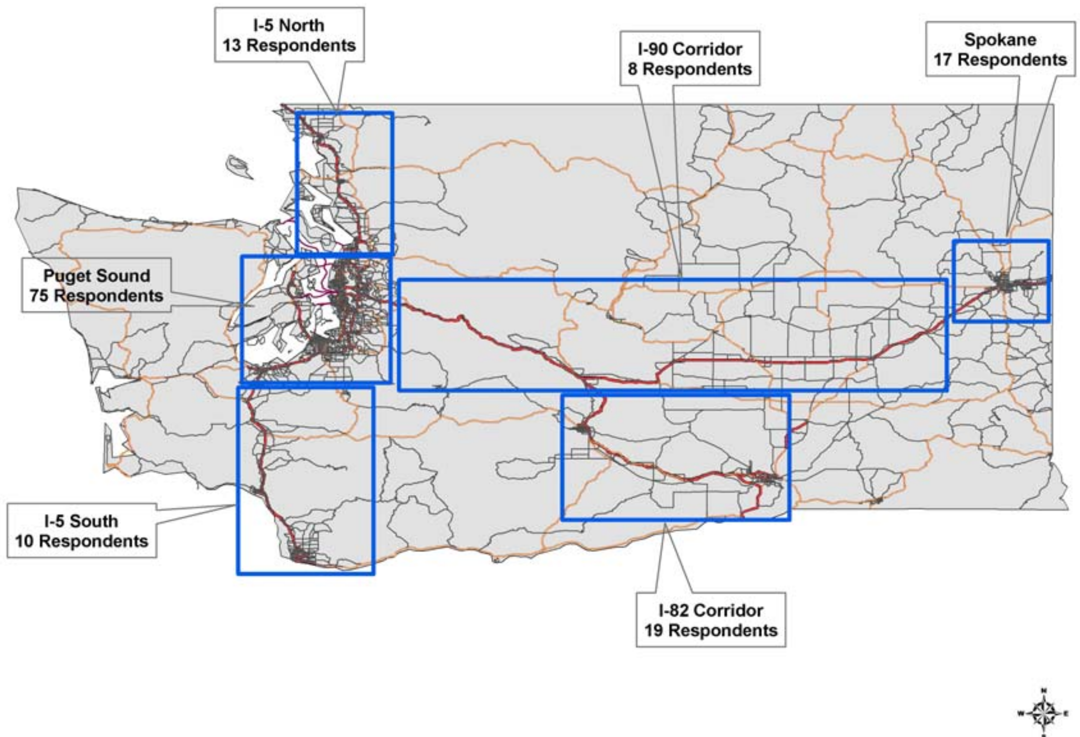

Figure 1.1. Sample Geographic Coverage Areas

Warehouse Operations

The section on warehouse operations addresses three key characteristics commonly associated with warehouse/distribution centers: facility size, hours of operation, and type of products handled.

Facility size has a direct impact on operations and transportation usage. The number of companies in various facility size segments, ranging from 0 to 300,000+ square feet, is shown in Figure 1.2. Facility size for 57 % of the responding firms ranged between 0 and 40,000 square feet. The largest segment, containing 23 firms, fell in the 0 to 10,000 sq. ft. range, followed next by 22 firms in the 20,001 to 40,000 sq. ft. range. The average facility size among all respondents was 118,548 sq. ft., with the median and mode being 50,000 sq. ft. and 10,000 sq. ft. respectively.

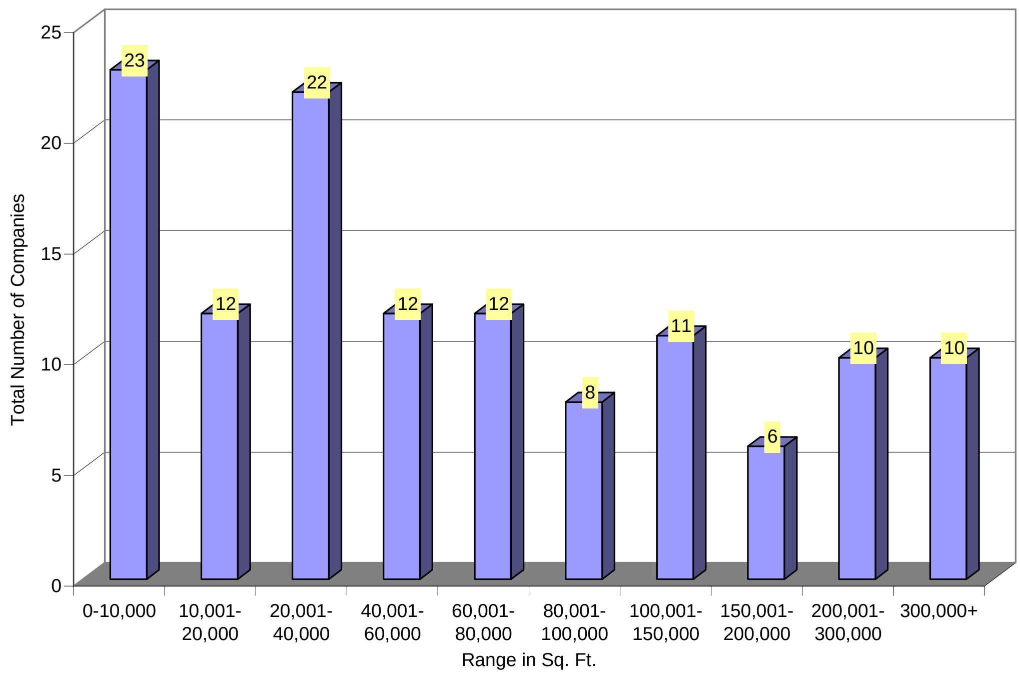

Figure 1.2. Square Footage of Facilities

In order to anticipate the volume of freight that is being moved during the day, and at what time of the day, respondents were asked to specify at what hours operations were conducted at their facility. The number of companies operating throughout the day is illustrated in Figure 1.3.

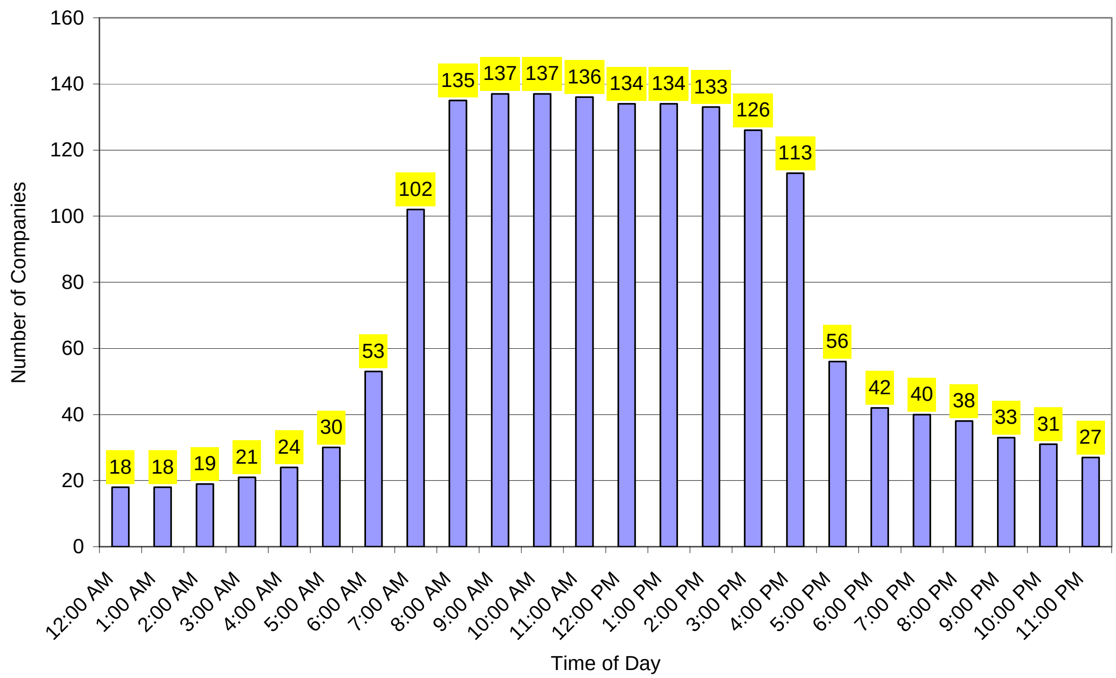

Figure 1.3. Hours of Operation

More than two-thirds of companies surveyed operate between the hours of 7:00 AM and 4:00 PM. A third of companies begin operations as early as 6:00 AM, but most companies curtail operations about 4:00 PM. In effect all companies are operating during the peak hours of the day when road and area congestion is typically the greatest. Obviously a majority of the companies schedule their delivery times in relation to their customer’s hours, typically between 8:00 AM and 5:00 PM. However, there are several companies that do receive and deliver shipments during the low traffic hours of the day.

Companies were also asked to specify the types of products received and shipped at their facility. Ten product type categories and the number of companies that distribute them are indicated in figure 1.4. An ‘Others’ segment was also included for any products that did not fall under the ten categories. Items listed in the 'Other' category were, for example, scrap metal and household goods such as furniture.

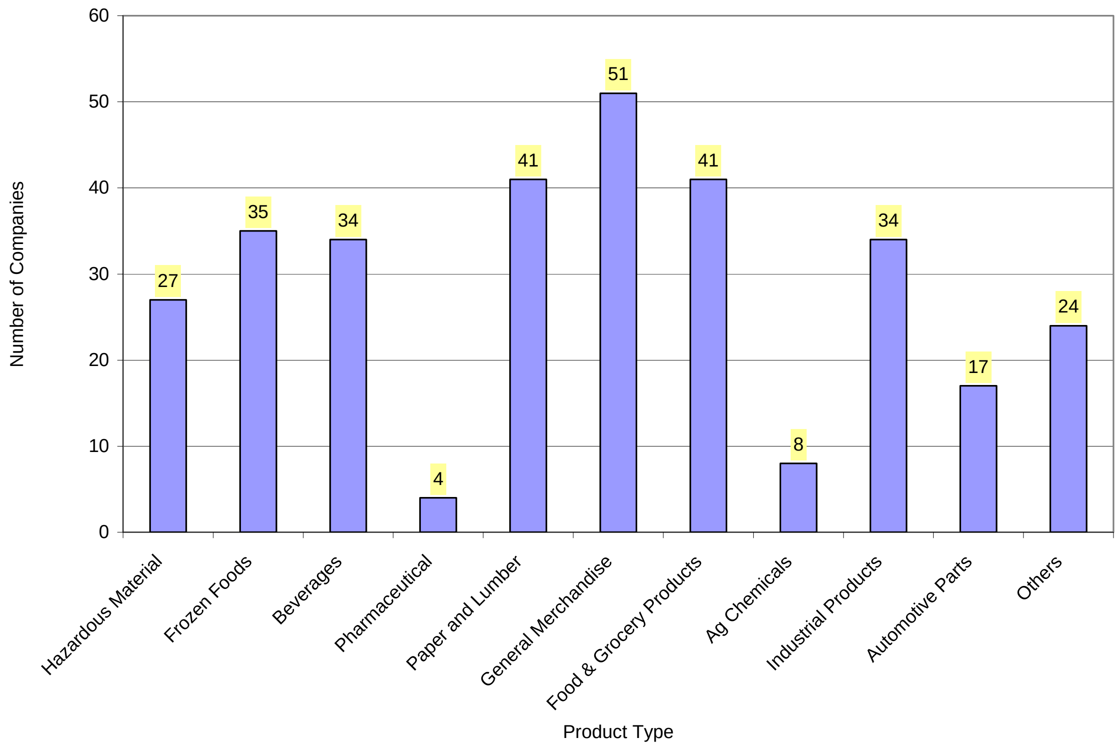

Figure 1.4. Products Distributed by Type

The most common product type being distributed is general merchandise. These type of products cover a broad range of products from electronics to apparel. Distribution of other retail goods such as food and grocery products was also common, accounting for close to one-third of all products handled. A substantial number of companies receive and ship paper and lumber related products as well. Nearly one quarter of respondents distributed some form of frozen foods (35) and beverages (34) and about the same number of companies distributed industrial products (34). Twenty-seven companies distribute some form of hazardous material on Washington roadways.

Intermodal Systems

In order to plan for current and future transportation infrastructure investments, it is useful to identify the modal services utilized by warehouse/distribution centers in transporting goods in each region of the state.

Inbound and outbound shipments by mode are sorted by region, and are shown in Figures 1.5 and 1.6. Truck transport is the primary mode used for inbound and outbound shipments in all six regions. A high percentage of freight movement in western Washington occurs along the I-5 corridor via ocean-truck. The use of rail-truck is popular in the I-82, I-5 North, and I-5 South regions. Of the six regions, the I-5 South and I-90 regions utilize rail the most in transporting inbound and outbound shipments.

As indicated in Figure 1.5, the Spokane region had the largest percentage of inbound shipments received via truck. Although the Puget Sound region had the smallest percentage transported only by truck, the area had the biggest proportion of freight being distributed by ocean-truck. The I-5 North region was the largest user of barge-truck at 1.7%, followed by Puget Sound with 1.1%. The corridor along I-5 South used rail most heavily at 7.8%. Spokane and I-90 followed close behind with 6.1% for each. For inbound shipments coming by air, I-5 South led with 2.9%, followed by the Puget Sound region at 2.1%.

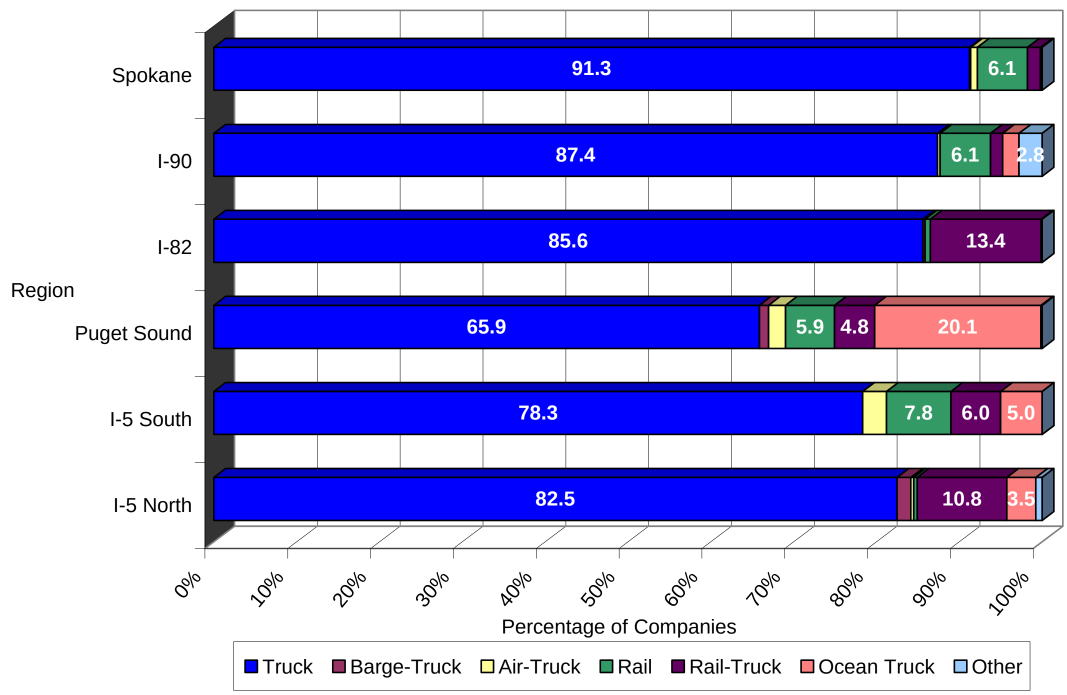

Figure 1.5. Regional Inbound Shipments by Mode

For outbound shipments, shown in Figure 1.6, the I-5 South corridor had the smallest amount of freight being transported by truck alone. However, this same region also transported the largest amount of freight via truck-ocean. The I-5 North region used truck-rail for outbound shipments the most. A noticable amount of outbound shipments in the I-90 region are transported by rail. The I-5 South region moved more outbound shipments by air than any other area. The Puget Sound region followed with 1.6% of all outbound shipments going by air.

The Spokane and Puget Sound regions, in Figure 1.6 were the only areas where outbound truck shipments were greater than inbound truck shipments. The Puget Sound corridor has the greatest difference with 11.9% more outbound shipments than inbound shipments via truck. The region also ships less than it receives via truck-ocean. There was a slight difference of 1.4% in the Spokane region for outbound versus inbound shipments via truck. Among the other four regions, I-82 had the greatest difference between inbound shipments and outbound shipments being delivered by truck. The difference may be attributed to the product types being distributed out of the region. This region is primarily agriculture based. Commodities from this area are likely transported to port terminals for export to international markets. This would explain the increase in usage for other modes such as Ocean-Truck.

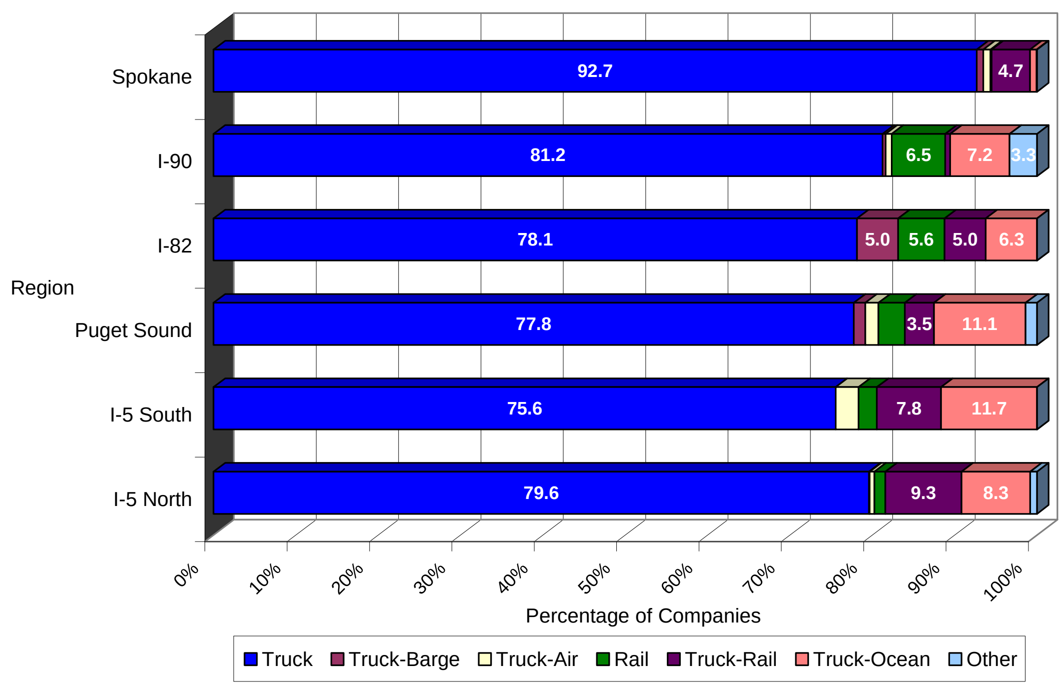

Figure 1.6. Regional Outbound Shipments by Mode

International Trade

Exports entering the U.S. from Canada and the Pacific Rim are transported principally by truck on Washington's roadways. Respondents were asked to identify the country of origin and destination of products handled at their facility. The results are shown in Figure 1.7. Within the state of Washington, there are generally more warehouses and distribution centers that import than export. Japan was the only country to which exports prevailed over imports. There were also a significant number of companies that import from Canada and China. Canada led as the country to which most exports were shipped, followed by Japan and China.

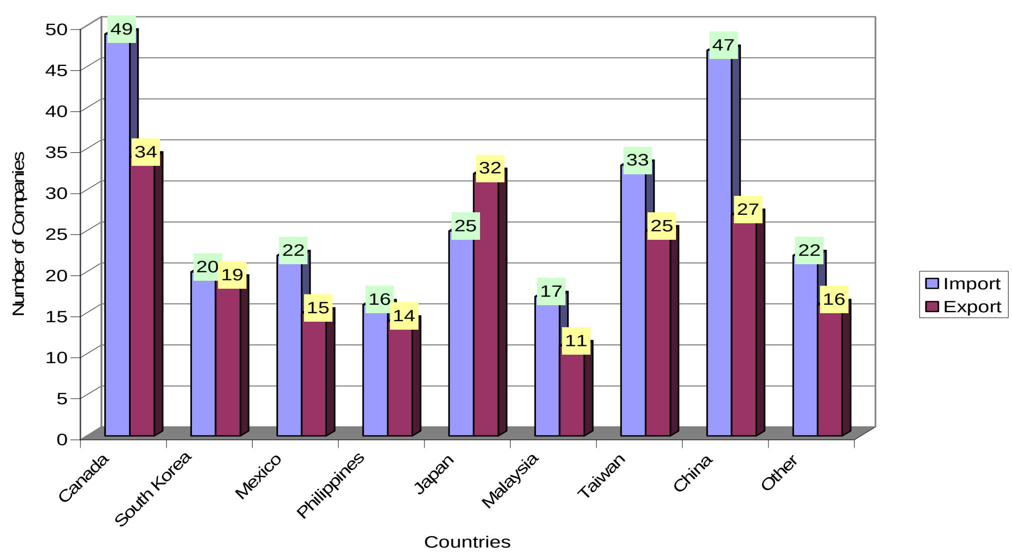

Figure 1.7. Country of Origin and Destination

Respondents were also asked to specify the type of products that are imported and exported at their facility, as shown in Figure 1.8. Thirty-three of 142 survey respondents listed general merchandise as the type of items they imported, making it the most common category shipped to Washington's warehouses and distribution centers. These products were also one of the most commonly listed product types for exports. Industrial products and food and grocery products were the next two largest import categories with 18 and 19 distributors handling each product type respectively. Paper and lumber, along with frozen foods, also lead as the most commonly exported products. The 'Others' category was included for any products that did not fall under the other ten product categories. Items contained in the 'Other' category were random personal effects and packaging materials.

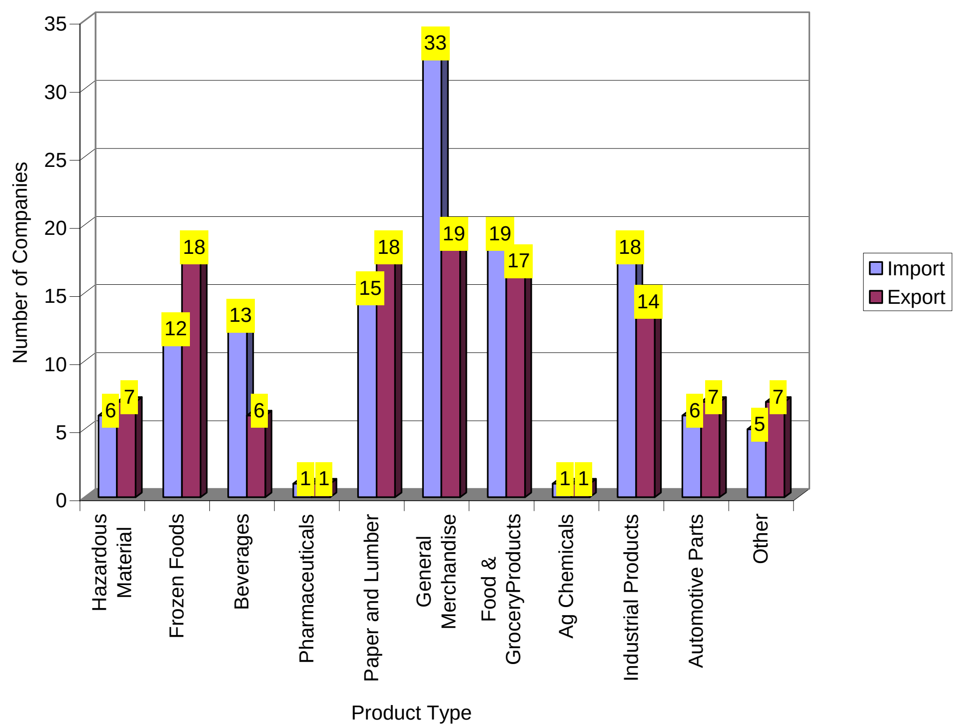

Figure 1.8. Products Imported & Exported by Type

Imported and exported shipments by mode type are shown in Figure 1.9. A large percentage of imports and exports are being transported via Ocean-Truck. The

Truck only category accounts for roughly 40% of the distribution of imported and exported goods along Washington's highways. The other four modes made up the remaining 10% for imports and 20% for exports. For both imported and exported shipments, only an estimated five percent travel by rail. The Air-Truck and Rail-Truck modes were significantly lower. The percentages of shipments that are destined for export via Truck-Barge were almost equivalent to that of Rail. Most of these are container shipments bound for various seaports along the Northwest coast.

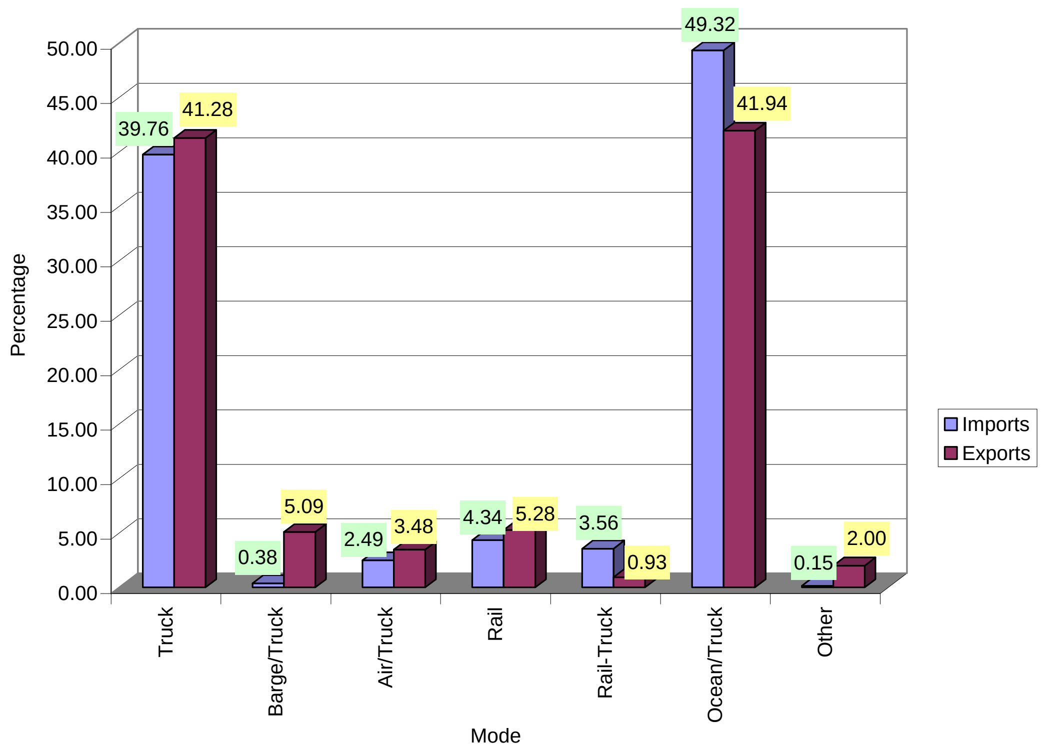

Figure 1.9 Import/Export Mode of Shipment

Other Transportation Related Issues

Respondents were asked to identify the type of freight chokepoints, whether physical, regulatory, social, or institutional that they would like to see eliminated. They were also asked to describe how those chokepoints affect their business. Their responses are shown in Table 1.1 under five main groups: Federal/State Regulations, Congestion, Weight Restrictions, Seasonal Road Closures, and Transportation Costs.

Most respondents in each of the six regions identify a particular highway or route where congestion or bottlenecks typically occur. There is also great concern among those in the industry over the continual rise in fuel costs. Two regions identified new regulations limiting driver times as being a major chokepoint. In addition, two regions indicated a desire to see a decrease in DOT regulations. Weigh station checkpoints were of significant concern to one region. Other problems or concerns identified in this study pertain to rising transportation costs, city/fuel tax increases, and an excessive amount of roadwork.

Table 1.1. Statewide Chokepoints

Type of Chokepoints	*Chokepoint Effects*	*Other Issues*
Federal/State Regulations: -Hours of Service -Driver Regulations -Class B License -Security/Customs -Fuel and City B&O Tax **Congestion:** -I-5 and I-405 -SR-167 Southbound -SR-392/I-2 Interchange -Hwy-12 **Weight Restrictions:** -Inconsistency on Interpretation of Rules and Regulations at Weight Stations **Seasonal Road Closures:** -Snoqualmie Pass -Portland to Tri-Cities **Transportation Costs:** -Longshoreman Strike -Increased Labor Rates -Fuel Tax -Rail Cost and Availability	**Federal/State Regulations:** -Increased Labor Costs -Impeded Delivery Time -Increased Transportation Costs -Slowdown of Freight Movement -Increased Operating Costs **Congestion:** -Excess Delays/Turnaround Time -Slowdown of Freight Movement -Lost Productivity -Increased Freight Volume **Weight Restrictions:** -Restricted Growth Opportunities & Business Activity -Increased Operating Costs -Operation/Labor Overtime -Delays/Missed Appointments **Seasonal Road Closures:** -Route Access/Operating Time -Increased Transportation Costs -Slowdown of Freight Movement **Transportation Costs:** -Impeded Delivery Time/ Productivity Loss -Increased Labor Costs -Increased Transportation Costs -Market Access	-Increased Fuel Costs -Poor Roadway Conditions -Rail Congestion and Availability -Border Crossing/Trade Problems -Current Infrastructure vs. Growth -Port Terminal Access -Freight Only Lanes -Equipment Availability -Environmental Regulations

Summary of the warehouse/distribution center industry in Washington

A wealth of unprecedented data was obtained from the warehouse/distribution center study. Analysis of this data provides further insight and understanding into how warehouse/distribution centers operate and how they utilize transportation. Data pertaining to the hours of operation, facility size, and type of products handled provided an imperative snapshot view of the characteristics associated with the warehouse/ distribution center industry in Washington.

Data from the study also indicated that a majority of warehouse firms are operating during the peak hours of the day when road and area congestion is typically the greatest. Moreover, insight was obtained in identifying what types of products are commonly managed by warehouses in the state. General merchandise was identified as the most common product type currently being distributed throughout the state. Further evaluation also indicated the portion of firms that are involved in distributing some form of hazardous material on Washington roadways.

Information identifying the popular modes of transportation provided critical insight into the type of infrastructure development needed for efficient freight mobility. For example, truck transport was identified as the primary mode used for inbound and outbound shipments throughout the state. However, the study also indicated that a high percentage of freight movement in western Washington occurs along the I-5 corridor via ocean-truck. For eastern Washington, there was a sizeable amount of freight movement that occurred by rail and rail-truck.

Data pertaining to the national and international movement of freight provided some understanding of the importance and operational characteristics of the import/export movement in the state. There are generally more warehouses and distribution centers that import than export. A majority of imports comes from either Canada or China, while a majority of exports are sent to South Korea and Japan. General merchandise products were indicated as the most common product types being imported and exported. Nearly half of all imported and exported freight arrives by ocean-truck, whereas the remaining half of all imports and exports are usually transported by truck alone.

Responses to the ranking of transportation issues and feedback on other transportation related issues allowed identification of the type of chokepoints and system deficiencies that occur in various freight corridors throughout the state. For instance, most respondents identify a particular highway or route where congestion or bottlenecks typically occur, such as SR-167 Southbound in the Puget Sound region. There was also concern indicated by firms in the industry over the continual rise in fuel costs.

Valuable insight into the operations and freight mobility needs of this particular industry was gained as a result of this study. Overall, analysis from this study is useful in evaluating the type of infrastructure development and investment needed to maintain economic vitality of this industry within the state. Furthermore, data generated from this study could also indicate the type of chokepoints and system deficiencies that occur in various freight corridors throughout Washington.

Literature Review of Warehouse Models

Over the years, there has been an abundance of literature discussing various modeling aspects of warehouse design and operations. The intent of this section is to briefly consider selected literature covering some of the fundamental applications or models of warehousing performed in past research. Literature identified below pertains to warehouse design, size, location, and the distribution network.

Cormier and Gunn (1992) reviewed literature covering the optimization of warehouse design and operations. The authors cover a wide array of warehouse problems in three specific categories: throughput capacity, storage capacity, and warehouse design. The three categories are discussed in detail, with the authors outlining the type of applications or models performed under each.

The overall objective of throughput capacity models is to maximize throughput or minimize costs associated with material handling, inventory holding, and reordering costs. These models center on the following key areas of warehouse activities: picking policies, batching policies, storage assignment policies, and dynamic warehouse control (Cormier, 1992). In each of these activities, the authors provide a brief synopsis of the different simulation, travel-time, and heuristic models that have been utilized.

Storage capacity models treat demand as either stationary or non-stationary. For those models that are stationary, the authors discuss past research regarding warehouse models that are intended to obtain the appropriate size needed to satisfy a service requirement or cost minimization goal. They then examine literature on non-stationary models that evaluate the fluctuation of warehouse capacity optimization at different times and its impact upon warehouse size. Dynamic programming algorithms and GPSS models are also addressed in this section as methods for maximizing storage space utilization within a warehouse.

Cormier and Gunn then report on the literature pertaining to warehouse design models. The authors separate their discussion of warehouse design models into either internal or overall design. Models focusing on internal arrangement address topics dealing with in-the-isle versus end-of-isle picking and scarce floor space allocation. Overall design problems mentioned by the authors pertain to optimization models such as the design of single and dual-command automated storage and retrieval systems.

The authors conclude by identifying the most important issues that are being generated from the literature review of warehouse models. According to Cormier and Gunn (1992), strategic decisions such as storage capacity and warehouse design impact long-term profitability. Therefore, the authors suggest that performing mathematical and simulation models in these particular areas are necessary. There is also indication that future research on tactical decisions, such as shared storage policies, and their role on travel time and rack size reductions seem worthwhile. For operational decisions in warehouse modeling, the authors recommend that heuristic modeling be prompt in conjunction with accurate results. In the end, obtaining an optimal solution in large integrated models would be difficult as a result of the different subsystems (i.e. costs associated with operation, transportation, and inventory) that are considered in the model.

A.K. Rao and M.R. Rao (1998) investigated alternative solution procedures for the sizing of warehouses. The general objective of the research is to show an alternative yet simple method of obtaining the optimal private warehouse size for a static problem without using linear programming routines. The authors consider a warehousing model for a company producing a single highly seasonal product which is being sent to only one warehouse. The goal is to minimize total warehousing cost over a finite planning horizon (Rao, 1998).

A review of previous methods used to find optimal warehouse size is first presented. An alternative method is then provided by the authors, outlining their theorem in obtaining a simple optimal solution. Also included is a discussion of three additional extensions that can be applied to the static problem to obtain an optimal solution. These three extensions involve costs varying over time, economies of scale in capital expenditure and/or operating costs, and stochastic version. The authors conclude by describing theorems outlining calculations necessary to locate the optimal value.

In an effort to aid in warehouse site selection, Korpela and Tuominen (1996) present a method drawing from the analytic hierarchy process (AHP) theory. Thus far, literature on warehouse site selection has primarily focused on cost-oriented methods. The objective in using AHP is to show an approach that utilizes both qualitative and quantitative characteristics to assist decision makers in the selection of an optimal site.

The authors provide a decision support system approach that is divided into four specific phases: defining the problem, defining the alternatives, analysis, and decision process. A practical example is given using an example company and public warehouse to demonstrate the four phased method. Once the company has selected the possible locations for a warehouse, an AHP-supported qualitative analysis is generated to identify key criteria to be included in the selection of a warehouse operator. Criteria are then prioritized in a hierarchy system and analyzed in relation to corporate goals. Once this has been done an evaluation of operator performance in relation to each criterion is considered.

After the AHP-supported qualitative analysis is done, analysis of all transportation and warehousing related costs are performed. The qualitative analysis and cost analysis is then combined by calculating the benefit/cost ratio for each alternative (Korpela, 1996). The ratio outcomes from each alternative will then indicate the best alternative solution to choose when selecting a site for a warehouse.

The authors conclude by stating that the proposed approach will enable decision makers to include multiple intangible criteria in the selection process. The approach also helps describes the relevant factors involved with warehouse selection and how they are interrelated. Furthermore, the quantitative analysis can be documented and shared with other interested parties involved in the warehouse site selection.

Rouwenhorst et al. (2000) reviewed literature pertaining to warehouse design and control problems. The overall objective of the work was to provide a basic framework for warehouse design limiting the discussion to the internal warehouse structure and operations. According to the authors, a majority of the research that has been published addresses primarily isolated problems of an analytical nature. They also identify the need for a reference model and design approach for warehousing systems.

In order to establish a framework for warehouse design, the authors provide a section in the research describing the processes, resources, and organization characterizations associated with warehousing. These characterizations involve complex decisions which must be structured in a hierarchical framework to effectively design a warehouse system. The authors then define warehouse design as a structured approach to the strategic, tactical, and operational decisions that are taken to meet certain outlined performance criteria (Rouwenhorst, 2000). A review of the various problems that occur in each of these decision levels is also discussed.

The research then provides an overview of papers centered on warehouse design problems. The authors separate the reviews by the three decision levels discussed above. They observe that most of research relates to warehouse organization on the tactical and operational levels. Very little of the literature reviewed addresses decisions on the strategic level. The need for more research on strategic issues is argued as a result of warehousing costs occurring at the early stage of design.

The authors conclude from their research that the extensive amount of literature regarding the subject of warehouse design is too scattered and analysis oriented. They indicate that future research on warehousing systems will and should concentrate on a systematic design approach that is inclusive of various models and methods. Future research will also evaluate the trade-offs between costs and operational performance of integrated systems.

Nozick and Turnquist (2001) present a modeling approach that optimizes the location of distribution centers while considering the trade-offs among facility costs, inventory costs, transportation costs, and customer responsiveness. A fixed-charge location model included with an inventory cost function is used to explore the above mentioned trade-offs. The use of a single product configuration with independent demand levels is considered within the model.

An illustration of the distribution of finished vehicles by an automotive manufacturer is used to demonstrate the application of the methodology. The study uses a set of 698 demand areas across the United States which represents potential distribution center locations. The study found that as the number of distribution centers increased, transportation costs decreased. Inventory costs however, increased at a quicker rate as the number of distribution centers increased. Fixed facility costs showed little significance as the number of distribution centers altered. Through the application of the model, the authors show that failure to include inventory costs would leave a major component of cost analysis out of the optimization of distribution center locations.

Nozick and Turnquist were able to demonstrate a modeling approach that integrated a discrete choice location model with inventory analysis and multiple objectives techniques. Furthermore, the authors were able to provide to decision makers a method for understanding the service-cost trade-offs of inventory costs, transportation costs, and service responsiveness when identifying the optimal distribution center location.

Jayaraman (1998) presents a FLITNET (Facility Location, Inventory, Transportation NETwork) model that builds upon previous work related to the interdependence between location, transportation, and inventory decisions during the design of a distribution network. The overall objective of the model is to determine the mode of transportation and level of inventory necessary to minimize the general costs associated with total inventory, transportation, and location issues. A mixed integer programming model subject to various distribution network design constraints is formulated to calculate the optimal solution while evaluating the different trade-offs that occur among the three issues.

The model consisted of four decision variables: total quantity of product from a plant to a warehouse by a certain mode, total quantity of product from a warehouse to an area of demand by a certain mode, and whether a warehouse and/or plant is open or closed. The model establishes eight different constraints that address demand satisfaction and capacity issues. The model also considers three modes of transportation in its formulation. In order to obtain optimal solutions, the model was performed using GAMS (generalized algebraic modeling system).

The program is performed under different scenarios to determine where facilities should be located. Each scenario is based upon the decision to open a certain number of plants and warehouses. The FLITNET model then is able to provide the optimal solution, identifying the appropriate locations along with the warehouse load ratio for that location. The model also chooses the best transportation mode to utilize in transporting the product to the warehouse. Overall these results offer decision makers the ability to pick the best location for plants and warehouses, as well as the best mode in transporting the product to and from a facility. The author also suggests that the model can be used to determine how variation with the number of plants and warehouses will impact transportation modes and inventory based upon location in the distribution network.

In conclusion, facility, inventory, and transportation costs have significant impact in the design of a distribution network. Jayaraman formulates a model that effectively examines the effects that occur between transportation, inventory, and facility location simultaneously. The model provides helpful insight into the trade-offs that are commonly associated with the three types of costs.

Lee, Cetinkaya, and Jaruphongsa (2003) present a model that is developed to simultaneously compute optimal levels of inventory replenishment and outbound shipment release schedules for a third-party warehouse. The authors contend that shipment consolidation reduces distribution costs and is often neglected as an option in improving system optimization and costs savings. They attempt to examine the reductions in cost that occur in outbound shipments through shipment consolidation.

The authors consider in their analysis a final product that is being shipped from the manufacturer to a third-party warehouse that services a distribution center. The model applied in the research was a two-echelon dynamic lot-sizing model. The problem is to minimize total costs associated with inventory replenishment and holding costs, outbound shipment costs, pre-shipment costs, and customer waiting costs through shipment consolidation. Constraints applied to the model center on inventory balance equations that take into account pre-shipment and late-shipment considerations.

The authors form some assumptions in regards to the type of optimality properties needed to determine the solution in minimizing total costs. The first property states that if inbound replenishment occurs in a period, then there does not exist a previous replenishment period. The second property states that inbound replenishment occurs only when there is an outbound dispatch. Property three states that each replenishment period is therefore a dispatch period. For an optimal solution to exist, property four contends that each dispatch must satisfy demand for several consecutive periods. They theorize that the problem is when demand in each period is met by one dispatch. A second theory is then assumed, where at most one Less-Than-Truckload dispatch is made when there are two consecutive customer-regeneration points. The final property for an optimal solution assumes that the shortest path between manufacturer and the third-party warehouse and distribution center exists when at most, one Less-Than-Truckload period occurs.

Once the model is formulated using the optimal properties above, a polynomial time algorithm is implemented. This algorithm is used to calculate all arc costs associated with the reduced network to obtain the optimal solution. The authors demonstrate how the optimal solution can be obtained to enable decision makers to know how often and in what quantities inventory at a warehouse should be replenished. Moreover, outbound shipments schedules can be determined to reduce cost and utilize transportation resources more efficiently when meeting customer demand.

This section has reviewed selected literature dealing with several fundamental applications or models pertaining to warehousing. The objective of the research in this study is to determine the relationship of warehouse size, and the number of inbound/outbound truckloads based on warehouse functions in relation to facility location and international trade. The analysis should provide additional information that will enrich understanding of the warehousing industry and its operations.

CHAPTER 3

DATA AND METHODOLOGY

General Data

Data utilized in this study were generated from a mail survey conducted on Washington's warehouse/distribution center industry in the summer of 2004 by the Strategic Freight Transportation Analysis (SFTA) program at Washington State University. A total of 142 companies, or 16%, of contacted companies returned useable survey responses, broadly geographically dispersed through the state.

The list of surveyed firms used in this study was compiled from sources within numerous agencies at the local, county, state, and federal levels. Information was obtained through regional economic development offices, city business license/treasurer departments, and the Washington State Department of Revenue. Additional firm names were also acquired through industry contacts and internet searches.

Significant effort was made to obtain data that would yield a statewide population of firms that are representative of the industry. Other organizations such as the Warehousing Education and Research Council, an association of distribution professionals, encountered problems when trying to obtain credible and verifiable data related to private warehouses nationally (Maltz, 2002). To insure that the data was reliable and presented an accurate picture of the industry, the list was contrasted and compared to different sources. For example, records from the Washington State Department of Revenue were compared against all city and county business license lists.

The final geographical distribution also followed the known distribution of warehouses and distribution centers within the state of Washington as indicated in a Washington Department of Transportation Freight Update report (Ivanov, 2004).

Subset Data

All data utilized in the research of this report were categorized into five subsets for detailed analysis. The first set of data contains information on all 142 observations collected in the study and reflects the statewide industry. The other four subsets are based on the warehouse's facility location and involvement in international trade. The dataset for facility location was based on the facility's location in eastern or western Washington. Eastern warehouse facilities are classified as those located along the I-90, I-82, and Spokane corridors. Western warehouse facilities are those located in the I-5 North, I-5 South, and Puget Sound corridors. The other two data subsets reflected whether a warehouse was involved in international trade.

The total number of responses contained in each of the four subsets is the following: Western Washington-97, Eastern Washington-44, International Trade-93, and Domestic Trade-48. Reference can be made to Appendix A, Table A.1 and Table A.2, for further quantitative and qualitative information on these data subsets.

Methodology

A multiple linear regression utilizing SAS (Statistical Analysis System) was performed to evaluate the relationships between various warehouse functions or characteristics. The REG procedure, by means of the stepwise model selection procedure, was used to run the regression models within SAS. The stepwise procedure was chosen as an appropriate procedure for identifying which independent variables of warehouse functions best describe the dependent variables of warehouse size and the number of inbound and outbound truckloads as indications of firm capacity utilization.

The stepwise function was chosen from nine model-selection methods available in the REG procedure. In the stepwise function, variables are added one at a time to the model. After a variable is added, the method then looks at all the variables within the model and deletes any variable that does not produce an F statistic that is significant enough to stay in the model. Once this is done, the method moves forward to the next available variable. The procedure ends when every variable in the model is significant at the entry level, with the remaining outside variables having no significant F statistic at the entry level (SAS, 1990).

This method was selected to be implemented as a result of the strong multicollinearity that exists within the datasets and among variables used in this study. For example, a strong relationship is likely to exist among such variables as the number of bays, the number of employees, and square footage of a facility. The Stepwise function is therefore employed to counteract any multicollinearity between variables occurring within the model. Again, this particular method selects the appropriate variables to be applied within the model based in relation to its F statistic, thereby ensuring that results generated from the regression model will be as precise as possible.

Variables

Three distinct dependent variables were analyzed using linear regression: Square Footage, Number of Inbound Truckloads, and Number of Outbound Truckloads. Square footage is a direct indicator of the size of the facility. The number of inbound and outbound truckloads were chosen to be related to the type of infrastructure development needed to maintain efficient freight movement in the state of Washington or alternatively, as an indicator of infrastructure consumed.

The following warehouse characteristics reflecting size and capacity were used as dependent and independent variables in the regression analysis. Dependent variables: *Intrucks* represents the total number of inbound truckloads, *Outtrucks* indicates the total number of outbound truckloads, and *Sqft* describes the square footage of a facility. Independent variables included such characteristics as *Bays*, which indicates the total number of bays at a facility. This variable was included since more bays at a facility typically means a larger sized facility that can concurrently handle a larger volume of inbound and outbound truckloads. The same reason holds for the variable *Employ* which represents the total number of employees at the facility. *Cdock* describes whether a facility offers cross-docking as a service, where its value-added service is to move goods in and out of a facility without being stored and thereby maximizing warehouse space utilization while increasing truckload movement.

Inpay describes the average inbound payload weight per load. *Outpay* describes the average outbound payload weight per load. These two variables were included to determine if the size of the payload per vehicle was related to the number of inbound and outbound truckloads. *Instops* and *Outstops* are variables indicating the number of stops typically made to and from the facility and reflect the type of service/movement being provided. *Privflt* indicates whether a company uses its own fleet in transporting goods, while *Threepl* indicates whether a company uses a third-party logistic provider to distribute its goods. These two were added to the model to determine whether more or fewer truckloads will occur if a facility is utilizing its private fleet versus a third-party.

Prodnum represents the total number of products handled at a facility. This variable was added to investigate whether the number of products handled affects the number of inbound and outbound shipments. *Busnum* indicates the total number of business services such as assembly consolidation and labeling, which are offered at the warehouse facility. The number of services a facility offers is included to determine if more services require larger facilities and/or more or less truckload volume. *Modenum* represents the total number of mode capabilities available at that facility location. This variable is included to determine if facility size is greater with more mode availabilities and to investigate its relationship to the number of truckloads.

Facility type variables were also included in the models. *Public* represents a facility that is a public warehouse, such as Weyerhauser Inc. Co. *Cold* represents a facility that is classified as cold storage, such as Henningsen Cold Storage Co. *Contract* describes those facilities that are identified as contract warehouses such as Columbia Colstor Inc. *Distctr* is a distribution center/hub facility such as URM Foodservice and *Ofactype* is classified as any ‘Other’ facility type such as Del Monte.

Independent variables in each of the three models varied depending on the dependent variable being analyzed. A summary list of the dependent and independent variables used in each of the three models is provided with a unit indicator and description in Tables 3.1 to 3.3. Note that a numeral unit is any quantitative measure starting from zero on.

There is only a slight difference among variables included in the inbound and outbound truckloads models. Rationally, the number of inbound stops and average inbound payload are included in the inbound model. Whereas the number of outbound stops and average outbound payload are entered in the outbound model. Neither the number of stops nor average payload weight was included in the square footage model.

Table 3.1. Variables used in Inbound Truckload Analysis

Variable	Unit	Description
Dependent:		
Intrucks	Numeral	Total number of inbound truckloads
Independent:		
Bays	Numeral	Total number of bays at facility
Employ	Numeral	Total Number of employees at facility
Cdock	(1,0)	1 if facility offers cross docking, 0 if not
Inpay	Numeral	Average inbound payload weight per load
Instops	Numeral	Total number of stops made on the way to a facility
Privflt	(1,0)	1 if uses Private Fleet, 0 if not
Threepl	(1,0)	1 if uses Third-Party Logistic Provider, 0 if not
Prodnum	Numeral	The number of products handled at facility
Busnum	Numeral	The number of business services offered at facility
Modenum	Numeral	The number of mode capabilities offered at facility
Public	(1,0)	1 if Public Warehouse, 0 if not
Cold	(1,0)	1 if Cold Storage, 0 if not
Contract	(1,0)	1 if Contract Warehouse, 0 if not
Distctr	(1,0)	1 if Distribution Center, 0 if not
Ofactype	(1,0)	1 if Other Facility Type, 0 if not

Table 3.2. Variables used in Outbound Truckload Analysis

Variable	Unit	Description
Dependent:		
Outtrucks	Numeral	Total number of outbound truckloads
Independent:		
Bays	Numeral	Total number of bays at facility
Employ	Numeral	Total number of employees at facility
Cdock	(1,0)	1 if facility offers cross docking, 0 if not
Outpay	Numeral	Average outbound payload weight per load
Outstop	Numeral	Total number of stops made on the way from a facility
Privflt	(1,0)	1 if uses Private Fleet, 0 if not
Threepl	(1,0)	1 if uses Third-Party Logistic Provider, 0 if not
Prodnum	Numeral	The number of products handled at facility
Busnum	Numeral	The number of business services offered at facility
Modenum	Numeral	The number of mode capabilities offered at facility
Public	(1,0)	1 if Public Warehouse, 0 if not
Cold	(1,0)	1 if Cold Storage, 0 if not
Contract	(1,0)	1 if Contract Warehouse, 0 if not
Distctr	(1,0)	1 if Distribution Center, 0 if not
Ofactype	(1,0)	1 if Other Facility Type, 0 if not

Table 3.3. Variables used in Square Footage Analysis

Variable	Unit	Description
Dependent:		
Sqft	Numeral	Total square footage of facility
Independent:		
Bays	Numeral	Total number of bays at facility
Employ	Numeral	Total Number of employees at facility
Cdock	(1,0)	1 if facility offers cross docking, 0 if not
Privflt	(1,0)	1 if uses Private Fleet, 0 if not
Threepl	(1,0)	1 if uses Third-Party Logistic Provider, 0 if not
Prodnum	Numeral	The number of products handled at facility
Busnum	Numeral	The number of business services offered at facility
Modenum	Numeral	The number of mode capabilities offered at facility
Public	(1,0)	1 if Public Warehouse, 0 if not
Cold	(1,0)	1 if Cold Storage, 0 if not
Contract	(1,0)	1 if Contract Warehouse, 0 if not
Distctr	(1,0)	1 if Distribution Center, 0 if not
Ofactype	(1,0)	1 if Other Facility Type, 0 if not

CHAPTER 4

ANALYSIS

Introduction

In this chapter, three separate models designed to identify and measure those variables which have a significant influence on the square footage and the number of inbound and outbound truckloads of a warehouse facility is evaluated. A summary of those independent variables significant within each model is presented. In addition, the relative magnitude of each variable within each model is discussed, as well as the implications this has on the warehouse/distribution center industry. Finally, conclusions are offered regarding the overall significance of each model.

Inbound Truckloads

The Stepwise model selection procedure within SAS was used to identify which variables had the greatest explanatory value and therefore should be included in the model. All independent variables left in the inbound truckloads models were significant at the 0.15 level. Four warehouse characteristics or functions were chosen as being significant in explaining the total variation in the number of inbound truckloads entering a warehouse facility. These functions were whether a facility uses a private fleet, whether it offers cold storage services, and the total number of bays and business services offered by a facility.

Data analysis gathered from the Ordinary Least Squares procedure is presented in Table 4.1. Cold Storage was indicated as an extremely significant factor, with a probability of 0.0014. On average, a cold storage facility will have 64 more inbound truckloads per week than any other warehouse type. These types of warehouses typically service the food industry and various retail sectors located throughout the state. The considerable increase in truckload movement at this facility is likely related to the time-sensitive nature of products and the growth in continual demand throughout the year for various refrigerated items.

The second most significant factor is the total number of bays. As the number of bays at a facility increases, the number of trucks increases by approximately one additional truckload per week. These truckloads are expected to be hauling a bulk quantity of product that is stored and then later broken down and redistributed to retail outlets. The results from the model indicate that as the number of business services offered by a warehouse facility increases, the number of inbound truckloads per week increases by nearly 11. As mentioned in Chapter 2, warehouses are now offering a variety of value-added services to contend against industry competition while capturing additional profits. Therefore, the number of inbound trucks on Washington roadways is expected to grow as more warehouses begin to offer additional business services.

Another significant factor was whether a facility utilizes a private fleet in the distribution of inbound freight. Those warehouse facilities utilizing their own private fleet to transport goods have approximately 27 fewer truckloads per week arriving at the facility. This relationship may be due to the fact that warehouses using a private fleet may be smaller.

TABLE 4.1. Inbound Truckload Results - All Washington Warehouses

Model: All Washington Warehouses
Dependent Variable: Intrucks

Analysis of Variance
R^2: 0.3486

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	125,790	31,447	10.03	<.0001
Error	75	235,064	3,134.19		
Corrected Total	79	360,854			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	14.29	15.52	2,660.0	0.85	0.3599
Bays	0.897	0.325	23,813	7.60	0.0073
Privflt	-26.53	13.39	12,303	3.93	0.0512
Busnum	10.72	4.473	18,017	5.75	0.0190
Cold	64.32	19.35	34,634	11.05	0.0014

Four warehouses functions or characteristics were significant enough to be included in the inbound model. A total of 80 out of 142 observations were used in the regression analysis for the state of Washington. Just over a third of the variation in the number of inbound truckloads is explained by these four significant characteristics. It is apparent that there are other factors not included in the model that may explain a significant portion of the unexplained variation in the number of inbound truckloads.

Inbound Truckload Analysis of Eastern versus Western Washington Warehouses

Analysis was then conducted to distinguish between those warehouses located in eastern versus western Washington. The same warehouse characteristics or factors were used in developing both the eastern and western Washington models. Again, the significance level for these models was set at the 0.15 level. For eastern Washington, there were only three functions shown to be significant. These three functions were public warehouses, the total number of employees, and the total number of business services offered by a facility.

The most significant factor was the number of employees, shown in Table 4.2. As the number of employees at a facility rises, the number of inbound truckloads increases by approximately one per week. This may mean that the number of inbound truckloads in this region can quickly become significant as businesses in the area grow and expand their workforce, or in other words, as the number of inbound truckloads increases, more employees have to be added.

TABLE 4.2. Inbound Truckload Results - Eastern Washington

Model: Eastern Washington
Dependent Variable: Intrucks

Analysis of Variance
R^2: 0.5788

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	82,757	27,586	10.08	0.0002
Error	22	60,230	2,737.71		
Corrected Total	25	142,986			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-41.00	20.50	10,948	4.00	0.0580
Employ	0.879	0.258	31,790	11.61	0.0025
Busnum	20.49	12.20	7,722.6	2.82	0.1072
Public	64.69	26.02	16,916	6.18	0.0210

Another significant factor for eastern Washington is the total number of business services offered. As the number of business services increases, there are approximately 20 more inbound truckloads arriving at warehouse facilities each week. This increase is double the statewide average of the number of inbound truckloads related to increased business services for all warehouses in the state. The stronger volume of truckloads generated from business services indicates that eastern firms have successfully used value-added business services to attract new volume.

Cold storage facilities receive the most significant amount of inbound truckloads throughout Washington. However, the largest number of inbound truckloads in eastern Washington seems to occur with those facilities that serve as public warehouses. This facility will receive 65 more inbound truckloads per week than any other facility type in the area. This increase may be associated with the discussed upsurge in value-added services among eastern Washington warehouses. Furthermore, public warehouses are beginning to take on new roles and functions to meet changing customer needs. As these warehouses become a more integral part of their customers' supply chain, the number of truckloads in the area is likely to increase.

Overall, public warehouses, the number of employees, and business services explain approximately 58% of the total variation in the number of inbound truckloads for eastern Washington. These three warehouse characteristics appear to be the most significant indicators for policy makers to consider when evaluating the number of inbound truckloads for this region of the state. The remaining percentage of unexplained variation is likely associated with information not obtained from the original survey questionnaire.

Analysis conducted relative to the number of inbound truckloads in western Washington is shown in Table 4.3. Five warehouse functions were statistically significant: those facilities identified as ‘Other’, those that offer cold storage services, the total number of bays, number of employees, and number of mode capabilities available at a facility. The number of employees apparently has a negative relationship upon the number of inbound truckloads in western Washington.

As the number of employees increases, there are approximately 0.05 fewer inbound truckloads per week. This decrease may be associated with increased employee performance and warehouse capacity. For example, the handling process for a truckload at a particular facility might be restricted by the number of employees that are capable of effectively getting to the freight and moving it about. The warehouse facility may also not have the adequate space to store large amounts of inbound freight. Therefore, there is little need to hire additional employees.

Another reason is that warehouses located in western Washington may utilize technology to increase input/output performance within the facility. To illustrate this point, a distribution center may automate their warehouse with the use of automatic storage and retrieval systems (ASRS). This means that fewer employees are needed in the process of tracking and handling shipments. Moreover, fewer errors are made thereby generating efficient inventory control while reducing inventory (Ackerman, 1997).

TABLE 4.3. Inbound Truckload Results - Western Washington

Model: Western Washington
Dependent Variable: Intrucks

Analysis of Variance
R^2: 0.3482

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	74,848	14,970	5.13	0.0008
Error	48	140,129	2,919.35		
Corrected Total	53	214,976			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-14.91	16.09	2,505.7	0.86	0.3588
Employ	-0.046	0.029	7,290.6	2.50	0.1206
Bays	1.506	0.591	18,937	6.49	0.0141
Modenum	12.11	5.790	12,762	4.37	0.0419
Cold	70.97	28.30	18,357	6.29	0.0156
Ofactype	28.21	15.97	9,114.3	3.12	0.0836

As the number of modes available for a firm to use increases, there are twelve more truckloads arriving at western warehouses each week. The significant increase in truckload movement in western Washington is believed to be related to the close proximity of warehouses to various sea ports and international airports. Approximately 36% of all warehouses in western Washington have ocean-truck capabilities, while another 22% utilize air-truck capabilities.

For every facility that is classified as an ‘Other’ facility type, there are 28 more inbound truckloads per week. These facilities in western Washington are classified as a private warehouse, manufacturing facility, cross dock facility, or container terminal. According to a report on private warehouses by the Warehousing Education and Research Council, a majority of private warehouses are used by manufacturers and wholesalers

(Maltz, 2002). These types of facilities are typically located near a port where a large amount of inbound and outbound freight is managed daily from a multitude of transportation modes. Therefore, these facilities are likely to be involved with freight arriving into or departing from ports. As mentioned above, the increase of freight arriving at Washington ports will likely increase the number of facilities and truckloads in this region.

If a facility within western Washington is a cold storage unit, then the facility will handle approximately 71 more inbound truckloads per week than other facility types. The large number of truckloads for cold storage facilities in western Washington is likely due to the market size, population density, and overall demand of the area. The majority of the state's population and trade are along the western coast, where demand for quick turnaround of refrigerated products in the food service industry is the largest. Truckload volume will intensify as the population in this region grows.

Overall, the R^2 for the model of inbound truckloads in western Washington was 35%, which is not as high as the R^2 for eastern Washington. A total of 54 out of 97 observations were used in the regression for truckloads in western Washington, while only 26 out of 44 observations were usable for regression analysis on warehouses in eastern Washington. The R^2 will be typically be higher as the number of observations used in a model increases. However, it is apparent that factors shown to be significant for western Washington warehouses could explain just over a third of the variation in the number of inbound truckloads. Though the R^2 is low, the estimated parameters values provide helpful insight into which factors influence the number of inbound truckloads in the area.

There were distinct differences in the type of characteristics that impact the number of inbound truckloads in east versus western Washington. In eastern Washington, public warehouses, the number of employees, and total number of business services offered were considered to be the most significant. To remain competitive, the companies in this region will likely continue to provide additional value-added services and extra manpower, which will increase the number of inbound truckloads. For western Washington, workforce size, mode capability, facility type, and total number of bays were signified as key indicators in the number of inbound truckloads. Warehouses in this region will continue to emphasize these types of warehouse functions that will generate efficient freight movement while maintaining the inventory needed to supply local demand.

Inbound Truckload Analysis of Domestic versus International Warehouses

The number of inbound truckloads relative to warehouse involvement in international trade was also examined. Analysis will be presented first for domestic warehouses, which are not involved in the importing and exporting of products. Analysis of international warehouses, which are involved with importing and exporting, is then provided. Those warehouse functions that are statistically significant to domestic warehouses were those facilities identified as ‘Other’, those offering cross-docking services, the average payload weight for inbound shipments, the total number of bays, and the total number of employees at a facility.

As indicated in Table 4.4, cross docking, with approximately 17 truckloads, had the largest influence among warehouse functions or characteristics in relation to the number of inbound truckloads received at a Domestic warehouse. This finding is not unexpected since cross docking enables a company to move freight into and out of their facility without storing the product for long periods of time. Unlike international warehouses, these facilities may not need to store products for a specific duration while custom procedures and other international service requirements are performed. Therefore, these types of facilities are more likely able to handle additional freight.

TABLE 4.4. Inbound Truckload Results - Domestic Warehouses

Model: Domestic Warehouses
Dependent Variable: Intrucks

Analysis of Variance
R^2: 0.8346

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	14,829	2,965.73	19.17	<.0001
Error	19	2,939.3	154.70		
Corrected Total	24	17,768			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	7.737	6.010	256.34	1.66	0.2135
Employ	0.534	0.099	4,419.1	28.56	<.0001
Bays	2.617	0.652	2,490.5	16.10	0.0007
Cdock	16.94	6.447	1,067.6	6.90	0.0166
Inpay	- 0.0004	0.00012	1,461.7	9.45	0.0062
Ofactype	-14.30	5.359	1,100.9	7.12	0.0152

Considering the average inbound payload weight received at a domestic warehouse, there is a very small and negative effect upon the number of inbound truckloads arriving each week. For example, as payload weight increases, the number of truckloads per week only decreases by -0.0004. This result is logical, since a heavier payload will imply fewer truckloads. Nevertheless, the decrease in truckload volume is extremely minimal as a result of the various weight restrictions placed upon truck payload weight on federal and state routes in Washington.

As the number of bays increases, there are approximately 3 more inbound truckloads per week for domestic warehouses. The most common number of bays for these types of facilities at present is 12, with an average of 43 inbound truckloads per week. The largest number of bays at a domestic warehouse was 95. As the number of employees rises, there is only half of a truckload more per week received at domestic warehouses. This would indicate that domestic warehouses are likely to require a larger size workforce to handle increased truck volume at the facility. Furthermore, a domestic facility that is classified as an ‘Other’ facility type will also have a negative impact upon truckload volume. However, this impact is not as small as the effect from inbound payload. These facilities will have 14 fewer inbound truckloads per week arriving at the warehouse.

The five warehouse functions shown to be significant in the regression have a strong ability to describe the total variation in the number of inbound truckloads for domestic warehouses. The R^2 for the domestic model was 83%, which is the highest R^2 value for any inbound truckload model. The total number of observations used from the domestic warehouse dataset for analysis was 25 out of 48.

Warehouses that indicated they are involved with international trade were then analyzed. The results from the Ordinary Least Squares procedure for international warehouses are presented in Table 4.5. As with domestic warehouses, there were five statistically significant factors. These five factors were those facilities offering cold storage services, those using a private fleet, the average payload weight for inbound truckloads, the total number of bays, and business services offered at a facility.

TABLE 4.5. Inbound Truckload Results - International Warehouses

Model: International Warehouses
Dependent Variable: Intrucks

Analysis of Variance
R^2: 0.3942

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	127,745	25,549	6.38	0.0001
Error	49	196,293	4,005.98		
Corrected Total	54	324,038			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-21.46	24.75	3,010.8	0.75	0.3902
Bays	0.864	0.377	21,008	5.24	0.0264
Privflt	-35.02	17.27	16,467	4.11	0.0481
Inpay	0.0007	0.0005	9,155.4	2.29	0.1370
Busnum	14.64	6.363	21,209	5.29	0.0257
Cold	77.40	25.47	36,997	9.24	0.0038

Cold storage facilities were once again a dominant factor in relation to inbound truckload volume. On average, those facilities offering cold storage services will have 77 more inbound truckloads per week. This is likely due to the portion of time-sensitive or perishable products arriving or departing from the ports. Of all companies surveyed, approximately 16% of them import frozen foods products, with another 24%

exporting. These percentages indicate that cold storage facilities play an integral part in the movement of goods to and from international markets.

Private fleet was also an influential factor in the number of inbound truckloads arriving at international warehouses. Those facilities utilizing a private fleet have 35 fewer truckloads per week, reflecting that smaller firms use private fleets more. The number of inbound truckloads increases in small increments as payload weight increases for international warehouses. The increase on average for inbound truckloads was 0.0007.

The total number of inbound truckloads for international warehouses increases by approximately 15 truckloads per week as the number of business services offered rises. This is not surprising since many companies involved with international trade utilize warehouses that can provide extra business services such as labeling. Companies will likely continue to utilize warehouses that perform extra services for products destined to and from international markets.

Almost all inbound truckload models, except for eastern Washington, identified bays as being a statistically significant factor. From the results, it appears that an increase in the number of bays at a facility is considered significant. However, the increase in the number of truckloads coming into a facility is marginal, with only approximately one more truckload arriving each week.

The five significant factors indicated in this model are able to explain over a third (39%) of the variation in the number of inbound truckloads for international warehouses. Taking into account additional information such as warehouse-port distance may provide further explanation for the number of truckloads with regard to international warehouses. Otherwise, it is unclear what other potential information could provide further explanation.

As was the case for eastern and western Washington, there were distinct differences in the type of characteristics that impact the number of inbound truckloads for domestic and international warehouses. In domestic warehouses, cross-docking, the number of bays, the number of employees, the average inbound payload, and those facilities listed as ‘Other’ were all considered significant factors. These factors may indicate that domestic warehouses handle a significant amount of time-sensitive products, which are quickly received and then redistributed to other distribution/retail outlets. Key indicators for international warehouses were the number of business services, bays, average inbound payload, private fleet, and cold storage facilities. As mentioned earlier, these warehouses play an integral part in the movement of goods to and from international markets. These facilities will typically function as hubs, where products are continuously received and prepared for future distribution to ports and other distribution centers. It is anticipated that there will be more inbound truck movement as these facilities continue to increase such business services as cold storage and labeling.

Overall, for inbound truckload regression models, a cold storage facility appears to have the largest impact in relation to the number of truckloads arriving at warehouses facilities in Washington. The only model that did not have cold storage as the leading influencer was eastern Washington. For this region, public warehouses had the largest influence upon truckload volume, reflecting regional differences.

Outbound Truckloads

Regression analysis then identified and measured those warehouse functions that have significant influence upon outbound truck movement in the state of Washington (Table 4.6). Again, all independent variables left in the outbound truckloads models were significant at the 0.15 level. Those factors shown to be significant for outbound movement were the number of bays, cold storage facility types, and if a warehouse utilizes a third-party logistic provider.

TABLE 4.6. Outbound Truckload Results - All Washington Warehouses

Model: All Washington Warehouses
Dependent Variable: Outtrucks

Analysis of Variance
R^2: 0.4542

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	672,556	224,185	23.02	<.0001
Error	83	808,157	9,736.83		
Corrected Total	86	1,480,713			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	38.21	19.37	37,882	3.89	0.0519
Bays	3.410	0.417	651,694	66.93	<.0001
Threepl	-33.26	22.53	21,222	2.18	0.1436
Cold	45.84	29.70	2,3201	2.38	0.1265

The leading factor impacting outbound truck volume in Washington was facilities that offer cold storage. This type of facility will have approximately 46 more outbound truckloads per week than any other facility type. As was described in the analysis of inbound movement, the considerable increase in truckload movement at this type of facility may be related to the time-sensitive nature of products and the need for items to be refrigerated. In addition, the increase in the number of outbound truckloads for the entire state is likely correlated with the increase in the number of inbound truckloads.

As the number of bays increases, these facilities will have close to 3.5 more outbound truckloads per week. This is a small incremental increase for the total number of outbound trucks leaving warehouse facilities in the state. This may be a result of the small increase generated in the number of inbound truckloads as the number of bays rises. Furthermore, outbound shipments are usually shipped according to an agreed upon time schedule determined by when the customer can receive the product. For example, the number of trips from a facility will depend upon the hours of operation and availability of a retail outlet to receive those shipments arriving from the warehouse.

Facilities utilizing a third-party logistic provider will have significantly fewer outbound truckloads than facilities that do not utilize this form of service. This finding is opposite of results for inbound movement, where those who rely upon a private fleet have significantly fewer truckloads arriving at the facility. This is likely attributed to the demand of shipments being distributed by a third-party from the warehouse over time. For example, a soft drink company may utilize a private fleet to ship a large number of cans to a warehouse in one location to be used in the future by a local bottler. Over time, the bottling company then draws the appropriate number of cans from the warehouse, needed to meet demand, reflecting Just-In-Time practices.

Approximately 45% of the total variation in the number of outbound truckloads in Washington is explained by the three factors discussed above. These warehouse functions do a better job describing the total variation than those shown to be significant in the inbound model. For inbound movement, those key functions were only able to describe about a third of the total variation. However, in both cases, there still remains a significant amount of the variation unexplained.

Outbound Truckload Analysis of Eastern versus Western Washington Warehouses

Referring to Table 4.7, there is a significant increase of 103 more outbound truckloads per week for those facilities that are public warehouses in eastern Washington. The considerable increase in outbound movement is likely due to the fact that this type of facility in the same region was indicated to have more inbound movement than any other facility type. Furthermore, there may be a large number of companies that do not find it beneficial to establish their own warehouse/distribution center in this particular region. This may be attributed to the smaller market size of the Inland Northwest. These companies will tend to rely upon the services of a public warehouse to store and distribute their goods to and from the area.

The total number of employees was indicated as the only other factor impacting outbound truckload movement in eastern Washington. Those facilities that increase their labor force have approximately 1.3 more outbound truckloads per week. It is apparent that hiring additional labor will not significantly impact the number of truckloads leaving a facility on a weekly basis. Warehouses in this region appear to currently have the workforce and technology needed to manage the number of outbound shipments.

TABLE 4.7. Outbound Truckload Results - Eastern Washington

Model: Eastern Washington
Dependent Variable: Outtrucks

Analysis of Variance
R^2: 0.5769

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	452,163	226,082	19.09	<.0001
Error	28	331,677	11,846		
Corrected Total	30	783,841			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-15.73	26.09	4,308.5	0.36	0.5513
Employ	1.299	0.214	436,084	36.81	<.0001
Public	102.7	50.03	49,890	4.21	0.0496

The R^2 (58%) for outbound truckloads in eastern Washington was quite high considering that only two factors were shown to be significant. It is evident from this model that public warehouses are of major significance in relation to outbound truck movement for this area of the state. The only difference in warehouse characteristics shown to be significant for inbound versus outbound truckloads for eastern Washington was the number of business services offered for inbound. In either case, these characteristics were able to explain roughly the same percentage of variation in inbound and outbound truck movement.

The number of outbound truckloads relative to warehouse functions performed in western Washington was then examined. Three key factors were recognized as being significant for this model: ‘Other’ facility types, the total number of employees, and the number bays at a facility (Table 4.8). Those facilities that were identified as ‘Other’, such as private warehouses, container terminals, or manufacturing facilities, had nearly 43 more outbound truckloads than any other facility type in the region. These facilities tend to be located in or within close proximity to port areas, where outbound container movement continuously occurs. The increase is likely due to the functions of these facilities in picking up and/or dropping off goods to be distributed by ocean or air. As more companies expand their business globally, there will likely be more outbound movement from these facilities.

As the number of bays increases for western warehouses, the number of outbound truckloads departing each week increases by over two. The small increase may mean that these types of facilities require a substantial amount of square footage to facilitate any increase in the number of outbound truckloads. This may also be attributed to the availability and size of the workforce at a facility. An increase of bays will mean little if there is no employee or storage space available to handle these truckloads.

The total number of employees was also indicated as a factor impacting outbound truckload movement in western Washington. As the number of employees increases, there is only half a truckload more that is dispatched from the facility each week. As was the case in eastern Washington, it is clear that hiring additional labor will not significantly increase the number of truckloads leaving those facilities on a weekly basis in western Washington. Moreover, increasing the labor force in western Washington warehouses will not be as efficient as adding laborers in eastern Washington.

TABLE 4.8. Outbound Truckload Results - Western Washington

Model: Western Washington
Dependent Variable: Outtrucks

Analysis of Variance
R^2: 0.5896

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	410,842	136,947	24.90	<.0001
Error	52	286,025	5,500.48		
Corrected Total	55	696,867			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	20.87	14.15	11,964	2.18	0.1463
Employ	0.054	0.029	18,308	3.33	0.0738
Bays	2.234	0.506	107,055	19.46	<.0001
Ofactype	42.66	22.45	19,861	3.61	0.0630

The R^2 for outbound truckloads in western Washington was also noticeably high, considering that only three factors were shown to be significant. Facility types classified as ‘Other’, the number of employees, and number of bays explained approximately 59% of the total variation in the number of outbound truckloads for this region. When comparing inbound R^2 to outbound R^2, it is apparent that fewer significant factors for outbound truckloads are needed to explain a greater portion of the variation in the model. The remaining percentage of variation not explained may be attributed to information not included in the model. For example, identifying the final destination from the facility in relation to outbound truck movement may indicate which areas draw more truckloads than others.

In review, outbound truck movement in eastern Washington will significantly increase as companies continue to utilize the services of public warehouses in this region. Within western Washington, outbound truck movement will only increase marginally as the number of bays increases at a facility. Furthermore those facilities identified as 'Other' will likely continue to increase outbound truck movement as product moved by ocean and air increases. Overall, increasing the total number of employees in either region does not significantly increase the number of outbound trucks.

Outbound Truckload Analysis of Domestic versus International Warehouses

Those warehouse functions that are statistically significant to domestic warehouses are shown in Table 4.9. The three functions shown to be significant were the total numbers of products and employees at each facility, and whether a facility utilizes a third-party logistic provider. The total number of employees was the most significant factor influencing outbound truckload movement for domestic warehouses. There is just over one additional outbound truckload per week as the number of employees at these types of facility increases. This rate of increase is half a truckload more when compared to the number of inbound truckloads handled at a domestic warehouse. This difference in truckload volume may be related to the time it takes a worker to unload and stock items entering a facility. Once the item has been stocked, workers can then quickly gather the necessary products needed and load them onto an outbound truckload.

TABLE 4.9. Outbound Truckload Results - Domestic Warehouses

Model: Domestic Warehouses
Dependent Variable: Outtrucks

Analysis of Variance
R^2: 0.7618

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	467,578	155,859	24.52	<.0001
Error	23	146,202	6,356.61		
Corrected Total	26	613,780			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-24.15	30.09	4,091.6	0.64	0.4306
Employ	1.272	0.182	311,026	48.93	<.0001
Threepl	-71.54	34.052	28,058	4.41	0.0468
Prodnum	37.35	12.49	56,804	8.94	0.0066

Those warehouses that manage a wider array of products at their facility have approximately 37 more outbound truckloads per week. This increase in truckload volume is not surprising since these types of warehouses will require a greater number of truckloads to move a number of different products to a variety of different customers. Furthermore, truckloads leaving these types of facilities may transport smaller loads that are destined to various retail outlets.

The last significant factor impacting outbound truck movement for domestic warehouses was the use of third-party logistic providers. These types of facilities have 72 fewer outbound truckloads when outsourcing to a third-party logistic provider. As was the case for all Washington warehouses, this decrease in outbound movement may be attributed to the demand of shipments being distributed by a third-party from the warehouse over time.

In the end, the three warehouse characteristics or functions shown to be significant were able to explain 76% of the total variation in the number of outbound truckloads for domestic warehouses. Compared to the R^2 of the number of inbound truckloads for domestic warehouses, there were fewer warehouse functions needed to explain the variation. However, the R^2 for inbound truckloads was higher than the outbound.

Results from the Ordinary Least Squares procedure on outbound truck movement for international warehouses are shown in Table 4.10. The number of bays, cold storage services, and the total average payload weight for outbound shipments were shown to be significant factors. Contrasting with inbound movement, the most significant factor in the outbound model was the total number of bays at a facility. As the number of bays increases, there are approximately 3 more outbound truckloads per week for international warehouses. As mentioned earlier, this small increase in truckload volume may be attributed to the storage availability and size of a facility.

A warehouse offering cold storage facilities was the next most significant factor. Facilities offering this type of service will have approximately 79 more outbound truckloads per week than any other facility type. As indicated earlier, a significant number of inbound truckloads arrive at international warehouses offering cold storage services. Furthermore, this increase in outbound movement may be the result of the various perishable products such as fruits and vegetables that need to be imported into or exported from the region quickly. These products are time-sensitive and require refrigerated storage as they are moved.

TABLE 4.10. Outbound Truckload Results - International Warehouses

Model: International Warehouses
Dependent Variable: Outtrucks

Analysis of Variance
R^2: 0.5686

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	492,882	164,294	24.60	<.0001
Error	56	373,976	6,678.15		
Corrected Total	59	866,858			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-1.975	15.41	109.73	0.02	0.8985
Bays	2.958	0.382	3,99622	59.84	<.0001
Outpay	0.0003	0.0002	17,418	2.61	0.1119
Cold	78.82	28.32	51,733	7.75	0.0073

The average outbound payload weight was indicated to be the least significant of the three warehouse functions or characteristics. As the average payload weight increases, the number of truckloads leaving a facility increases marginally at 0.0003. Again this is likely due to the restrictions placed on truckload weight on Washington roads or to the product characteristics of the load.

The three functions or characteristics shown to be significant were able to explain approximately 57% of the total variation in the number of outbound truckloads for international warehouses. These warehouse functions were able to explain significantly more in terms of total variation for outbound truckloads than those functions shown to be significant for inbound movement to international warehouses. However, in both models, there still remains a significant portion of the variation for these types of warehouses that are unexplained from the data generated from the survey.

In domestic warehouses, the total number of products handled at the facility, the number of employees, and those facilities that use third-party logistic providers were all considered significant factors. There is only a slight increase in outbound truck movement as the number of employees at a facility increases. Those domestic warehouses that handle a wide variety of products will see a noticeable increase in the number of outbound truckloads per week. Meanwhile, facilities using third-party logistic providers have significantly fewer outbound truckloads per week. The lower number of truckloads may be related to the availability of different transportation modes accessible to third-party logistic providers.

For warehouses involved with international trade, the number of bays, average outbound payload, and whether a facility offers cold storage services were considered significant. An increase in the number of bays and outgoing payload generate only marginal increases in truck movement. International warehouses that also provide cold storage services will have significantly more outbound truckloads than any other facility type.

Square Footage

Identifying and measuring those warehouse functions or characteristics which have a significant influence on square footage of a facility were also undertaken. This analysis provides policy makers with information to help them anticipate and provide the infrastructure development and investment needed to maintain economic vitality of this industry in the state. The summary of the Ordinary Least Squares procedure for the square footage of all warehouses surveyed in the state of Washington is presented in Table 4.11. Five statistically significant warehouse functions were based upon facility type such as those identified as contract warehouses or as ‘Other’, the total number of employees, total number of bays, and if a facility utilizes a private fleet.

Overall only 16% of all warehouses surveyed are identified as contract warehouses. The small number of users and size limitation associated with contract warehouses may signify that companies prefer to use the services of public and private warehouses. Warehouse facilities that are classified as contract warehouses have 38,177 fewer square feet than any other type of warehouse in the state. This is possibly due to the fact that the function of a contract warehouse is to contract out space to an individual who then manages the operations of the facility. Usually a contract is set for a specific size which prevents the user from expanding or decreasing the space, generating a barrier for the user in adjusting storage capacity to meet demand (Ackerman, 1972).

Another facility type that was shown to be significant in relation to the total variation of square footage for Washington warehouses were facilities identified as ‘Other’. These types of facilities compared to others will have approximately 35,000 fewer square feet. Again, these types of facilities were shown to be primarily private warehouses or manufacturing facilities. It can be expected that manufacturing facilities will typically maintain only enough storage space to store any overflow of product or keep emergency stock of raw material on hand when needed.

TABLE 4.11. Square Footage Results - All Washington Warehouses

Model: All Washington Warehouses
Dependent Variable: Sqft

Analysis of Variance
R^2: 0.7950

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3.02368E12	6.04736E11	84.52	<.0001
Error	109	7.7987E11	7,154,770,734		
Corrected Total	114	3.80355E12			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	64408	15144	1.294109E11	18.09	<.0001
Contract	-38177	21067	23,495,465,811	3.28	0.0727
Ofactype	-34667	18754	24,447,717,602	3.42	0.0672
Employ	121.39	27.418	1.402586E11	19.60	<.0001
Bays	4341.6	285.07	1.659573E12	231.95	<.0001
Privflt	-43881	16358	51,487,165,286	7.20	0.0084

Warehouses that employ additional labor have an average of 121 more square feet. The amount of square footage as the number of employees rises may appear small. However, this can quickly change as more room is needed to allow any additional labor to effectively move freight around a facility, while the space also increases the need for employees. Currently, the average number of employees at a Washington warehouses facility is 85 total employees.

The overall square footage of a facility also increases by 4,342 square feet as the number of bays increases. At present the average size of a facility in Washington is approximately 110,952 square feet, containing an average of 18 loading bays. These results give policy makers some general indication of the overall impact on the size of a facility as the number of employees and bays rises for facilities in Washington.

Warehouses will be close to 44,000 square feet smaller if firms utilize their own private fleet. Currently, nearly one-third of all companies within Washington use private fleets in distributing freight to and from the warehouse. Another third of companies use both a private fleet and third-party logistic providers. The use of private fleets may be related to cost savings and the industry's emphasis on Just-In-Time delivery. By maintaining its own fleet, a company can deliver products to the warehouse when needed, thereby avoiding the need to maintain excess inventory on hand. This lowers storage space and inventory costs.

A significant amount of the total variation within square footage is explained by these five functions or characteristics. This is not surprising since the number of employees and bays within a facility generally has a direct correlation with facility size. The remaining portion of variation not explained from this model may be attributed to data not included in the models calculations, such as missing information on square footage, given that there will be some items that will require more space than others. Overall, these warehouse functions or characteristics successfully explain nearly 80% of the total variation.

Square Footage Analysis of Eastern versus Western Washington Warehouses

Analysis was then conducted to measure which variables have significant influence on square footage in eastern versus western Washington. For eastern Washington, there were only two factors found to be significant (Table 4.12). The more significant of the two was the total number of bays. The increase in the number of bays for facilities in western Washington increases by over 7,000 square feet. This amount is significantly larger compared to the additional square footage indicated in the Washington warehouse model. This may be a result of the size of products being stored in eastern warehouses. For example, eastern Washington produces a significant amount of agricultural commodities such as apples or potatoes that require a larger amount of storage space than would radio units.

TABLE 4.12. Square Footage Results - Eastern Washington Warehouses

Model: Eastern Washington
Dependent Variable: Sqft

Analysis of Variance
R^2: 0.8108

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	7.218005E11	3.609003E11	66.41	<.0001
Error	31	1.684784E11	5,434,788,682		
Corrected Total	33	8.90279E11			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	81444	22241	72,877,595,233	13.41	0.0009
Bays	7322.4	677.25	6.353294E11	116.90	<.0001
Privflt	-91786	26040	67,522,135,435	12.42	0.0013

Facilities will be 92,000 square feet smaller when firms operate a private fleet. The decrease in square footage for facilities in this region is 52% greater than that of all warehouses using private fleets throughout the state. Warehouses operating a private fleet in this region may provide service primarily within the facility’s local area. Therefore, these types of facilities may not require large storage space and can rely on their own fleet to distribute freight destined for local customers.

The R^2 for this particular region was estimated at approximately 81%. This high value indicates that the total variation in warehouse size in eastern Washington is basically explained by the total number of bays and whether a facility operates a private fleet. Evidently the total number of products a facility handles is not significant. However, the remaining 19% may be attributed to a particular product type being stored. As mentioned earlier, size of a facility may be determined by the type of product being handled.

The summary of the Ordinary Least Squares procedure for the square footage of all those warehouses located in western Washington is presented in Table 4.13. Five specific warehouse functions were chosen as being statistically significant. These five characteristics were warehouses that are classified as ‘Other’ facility types, facilities that offer contract services, warehouses using third-party logistic providers, the total number of bays, and number of employees at a facility. Of the five denoted above, the only two that had a significance level of <.0001 were the total number of bays and number of employees at a facility.

TABLE 4.13. Square Footage Results - Western Washington Warehouses

Model: Western Washington
Dependent Variable: Sqft

Analysis of Variance
R^2: 0.8547

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2.490032E12	4.980064E11	88.25	<.0001
Error	75	4.23227E11	5,643,026,555		
Corrected Total	80	2.913259E12			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	15755	16656	5,048,479,824	0.89	0.3473
Contract	-47700	20881	29,447,361,061	5.22	0.0252
Ofactype	-53991	21117	36,890,058,634	6.54	0.0126
Employ	119.71	24.425	1.355518E11	24.02	<.0001
Bays	4151.7	267.38	1.360498E12	241.09	<.0001
Threepl	29593	17846	15,517,522,435	2.75	0.1014

The increase in the number of bays for facilities in western Washington generates approximately 4,152 more square feet. As a result, there is a stark contrast in the size generated from an increase in the number of bays between eastern and western Washington warehouses. Again, this is assumed to be a result of the products handled at these facilities. Warehouses in western Washington may be handling general merchandise products such as radios that take less space than would products like potatoes.

The square footage of a facility in this region increases by approximately 120 additional square feet as labor increases. This increase in size is somewhat comparable to the overall increase in square footage for all Washington warehouses. The number of employees in relation to the square footage of eastern Washington warehouses is not significant. This would indicate that facilities in western Washington require a significant amount of labor and square footage to manage the daily operations and freight coming into and out of western warehouses.

In western Washington, facilities that offer contract services have approximately 47,700 fewer square feet than other facility types. Moreover, those facilities identified as 'Other' will be close to 54,000 square feet smaller than other warehouses in the same region. These two facility types were identified as being significant earlier when discussing square footage of all Washington warehouse in general.

There is a decrease in square footage for eastern Washington warehouses which operate their own private fleet. In western Washington, those warehouses that operate with the help of a third-party logistic provider will have nearly 30,000 additional square feet. This considerable increase may relate to the fact that as warehouses expand their operations, the need to outsource their logistical services increases.

The five warehouse functions shown to be significant in this model explain nearly 85% of the total variation in the square footage of western Washington warehouses. Overall, there were more factors that significantly influenced the square footage of facilities in western Washington than those in eastern Washington. This may indicate that warehouses in this region are more diverse and perform a multitude of functions that influence facility size, whereas those facilities in eastern Washington are presumably similar in nature.

In both eastern and western Washington models, the selected factors were shown to explain a significant portion of the overall variation in square footage. Warehouses in eastern Washington will typically be smaller if they operate their own private fleet. In addition, as the number of bays increases, the overall square footage of a facility will increase considerably. Again, this significant increase is believed to be associated with the type of products that are typically handled at an eastern warehouse. This information was not included in the model.

Warehouses in western Washington that were identified in the survey as 'Other' will also have significantly less square footage than all the other facility types. Those facilities that offer contract services will be also be small. However, facility size in this region will increase as the number of employees and bays rises. Finally, western warehouses will typically be larger if their logistics are outsourced to a third-party provider.

Square Footage Analysis of Domestic versus International Warehouses

Analysis of the square footage for domestic and international warehouses is discussed next. Warehouse functions that are statistically significant to domestic warehouses are shown in Table 4.14. The total number of employees and the number of bays at a facility were the two most significant warehouse characteristics influencing square footage for domestic warehouses.

TABLE 4.14. Square Footage Results - Domestic Warehouses

Model: Domestic Warehouses
Dependent Variable: Sqft

Analysis of Variance
R^2: 0.6899

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	4.150736E11	2.075368E11	40.05	<.0001
Error	36	1.865295E11	5,181,375,635		
Corrected Total	38	6.016031E11			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-381.16	13903	3,894,414	0.00	0.9783
Employ	486.13	172.57	41,117,866,798	7.94	0.0078
Bays	3211.4	919.92	63,143,797,604	12.19	0.0013

Bays were identified as the most significant factor with a probability level of .0013. The square footage of these facilities is approximately 3,211 square feet larger as the number of bays rises. The square footage increase in relation to the number of bays for all warehouses within the state is significantly higher compared to that of domestic warehouses.

The average number of bays for domestic warehouses in Washington is shown to be only 12 bays, while the state average is 18. Evidently, the domestic warehouses do not require a significant amount of square footage for additional bays. This may be a result of the type of functions performed by domestic warehouses. No more than a third of all domestic warehouses offer any additional sort of business service to customers besides the basic unloading, storing, and loading functions.

As domestic warehouses increase their labor force, the size of these facilities becomes 486 square feet larger. Currently, there is an average of 56 employees employed at a domestic warehouse. It would seem from the estimates that these facilities require a substantial amount of square footage when adding employees. As mentioned above, it appears that these types of facilities are typically small in size and therefore do not need a large amount of labor.

These two characteristics were able to explain nearly 70% of the total variation in square footage for domestic warehouses. It is apparent from the data on these types of facilities that they are typically small. Moreover, the number of employees and bays will have significant influence upon the size of domestic warehouses within Washington.

Analysis is then implemented for those factors identified as significantly influencing the square footage of international warehouses. Estimates generated from the Ordinary Least Squares procedure are shown in Table 4.15. There are five warehouse functions shown to be significant. These five were warehouses identified as 'Other' facility types, those that offer contract services, warehouses operating their own private fleet, the total number of bays, and number of employees at a facility.

The total number of bays is shown to be the most significant warehouse function for international warehouses at the <.0001 level. Warehouses will be approximately 4,360 square feet larger as the number of bays increases. As international trade grows, warehouses will likely construct facilities that have a larger number of bays to manage the continuing rise in imported and exported products within the region. In addition, these types of facilities will require additional space as companies continue to offer a wide array of international business services at the warehouse level.

TABLE 4.15. Square Footage Results - International Warehouses

Model: International Warehouses
Dependent Variable: Sqft

Analysis of Variance
R^2: 0.8228

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2.543494E12	5.086988E11	64.99	<.0001
Error	70	5.478908E11	7,827,011,838		
Corrected Total	75	3.091385E12			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	74518	17393	1.43665E11	18.36	<.0001
Contract	-58010	26716	36,902,555,137	4.71	0.0333
Ofactype	-52937	24712	35,916,913,621	4.59	0.0357
Employ	117.06	29.017	1.273779E11	16.27	0.0001
Bays	4360.6	319.61	1.456967E12	186.15	<.0001
Privflt	-45167	20907	36,529,019,653	4.67	0.0342

The total number of employees is the next most significant warehouse characteristic. International warehouses are approximately 117 square feet larger as facilities increase their labor force. The labor force for these warehouses is anticipated to grow due to increasing trade with Pacific Rim countries. Nevertheless, this growth may increase only marginally as the technology used in international warehouses to move and track freight becomes more efficient. Therefore, the number of employees at these facilities will not considerably alter the overall square footage of an international warehouse.

International warehouses operating with their own private fleet will typically be just over 45,000 square feet smaller than other warehouses. These warehouses may be able to utilize their own private fleet to effectively manage when and how much imported and exported goods come into and leave from the facility. This allows a company to maintain a smaller size warehouse.

Those facilities that offer contract services will have approximately 58,000 square feet less than other facility types. Likewise, those facilities that were identified as 'Other' will be close to 53,000 square feet smaller than other types of warehouses involved with international trade. These two facility types were also indicated as being significant in relation to square footage for warehouses in western Washington and for all warehouses in general for the state of Washington. Once again, manufacturing companies will likely outsource a majority of their warehousing to a third-party. Manufacturers are then able to keep their on-site warehouses small, storing only the amount of material necessary for unanticipated occasions.

The five warehouse functions shown to be significant in this model explain approximately 82% of the total variation in the square footage of international warehouses. A higher percentage of variation is explained in the international warehouse model compared to the domestic warehouse models. However, there were a greater number of observations used in the international model than in the domestic models. This may explain the higher percentage of variation explained for international warehouses.

Finally, it appears that the size of both domestic and international warehouses is influenced by the total number of bays and number of employees within a facility. For international warehouses, other key factors influencing square footage related to whether a facility type was identified as ‘Other’, those that offered contract services, and facilities which operated a private fleet. Apparently the size of warehouses, particularly those involved with international trade, was not significantly influenced by such factors as total number of products handled or the number of business services offered.

An overview of the independent variables shown to be statistically significant for each of the three regression models is presented in Table 4.16. The number of useable observations versus the total number of observations of each dataset is included. In addition, the R^2 values calculated for each dataset regression are shown.

Analysis of the overall data indicates that the number of bays and the number of employees are significant for a large majority of the models. However, the number of bays for eastern Washington was shown to be insignificant for inbound and outbound truckloads. The insignificance is likely attributed to the basic operations being performed by these facilities in this region. These facilities may not handle the volume needed to generate an increase in the number of bays.

Additionally, the number of employees was insignificant for the following models: Inbound-All and International, Outbound-All and International, and Square Footage-Eastern. The number of employees may not be significant due to the basic operations and volume handled in eastern Washington warehouses. For international warehouses, the number of employees may not significantly influence the number of inbound/outbound truckloads as a result of new technology being implemented to more efficiently move freight at the facility, excluding the need for additional labor.

Table 4.16. Overview of Regression Results

Inbound Truckloads			
	Sample Size Used	R^2	Significant Variables
All	80 of 142	0.3486	Bays, Privflt, Busnum, and Cold
Eastern	26 of 44	0.5788	Employ, Busnum, and Public
Western	54 of 97	0.3482	Employ, Bays, Modenum, Cold, and Ofactype
Domestic	25 of 48	0.8346	Employ, Bays, Cdock, Inpay, and Ofactype
International	55 of 93	0.3942	Bays, Privflt, Inpay, Busnum, and Cold
Outbound Truckloads			
	Sample Size Used	R^2	Significant Variables
All	87 of 142	0.4542	Bays, Threepl, and Cold
Eastern	31 of 44	0.5769	Employ and Public
Western	56 of 97	0.5896	Employ, Bays, and Ofactype
Domestic	27 of 48	0.7618	Employ, Threepl, and Prodnum
International	60 of 93	0.5686	Bays, Outpay, and Cold
Square Footage			
	Sample Size Used	R^2	Significant Variables
All	115 of 142	0.7950	Contract, Ofactype, Employ, Bays, and Privflt
Eastern	34 of 44	0.8108	Bays and Privflt
Western	81 of 97	0.8547	Contract, Ofactype, Employ, Bays, and Threepl
Domestic	39 of 48	0.6899	Employ and Bays
International	76 of 93	0.8228	Contract, Ofactype, Employ, Bays, and Privflt

Results also indicate that not all facility types shown to be significant for inbound truckloads were also significant for outbound truckloads. For example, cold storage facilities were significant for inbound but not for outbound truckloads for western Washington warehouses. This may be due to bulk shipments of products entering a facility, where it is then broken down to smaller size. To illustrate this, some cold storage facilities in western Washington process and distribute a significant amount of seafood that originally arrives in bulk form, but then is transported in smaller shipments destined for retail.

Domestic warehouses identified as 'Other' were shown to be significant for inbound truckloads but not for outbound. Some of these facilities were identified as manufacturing facilities, where a significant amount of raw material is brought in to produce a good that is then distributed to the market. Private warehouses were also classified as 'Other'. These facilities may receive a larger number of inbound shipments containing various products from a host of different suppliers. These items are then consolidated and redistributed to retail outlets, generating less of a need for higher outbound truck movement.

In conclusion, domestic warehouses had the largest percentage of variation explained by variables shown to be statistically significant for inbound and outbound truckload models. The high R^2 may indicate that domestic warehouses and the operations performed within are very similar to each other. Domestic warehouses had the lowest R^2 value among all the datasets for total square footage. Apparently, additional information not captured in the survey is needed to explain the remaining variation. The largest R^2 value for total square footage occurs for warehouses located in western Washington. Again this may indicate that warehouses in this region are more diverse and perform a multitude of functions that influence facility size.

CHAPTER 5

SUMMARY AND CONCLUSION

Summary

The general purpose of this research was to investigate the operations and transportation usage of the warehouse/distribution center industry in Washington. As mentioned previously, three specific objectives were outlined for this research. The first objective was to provide a description of the common operations and functions performed in the warehouse/distribution center industry and assess those characteristics associated with warehouses in Washington. A literature review of warehouse models was provided in conjunction with a description of the basic functions, operations, types, trends and other characteristics associated with the warehouse/distribution center industry in Washington.

For the last two objectives, a multiple linear regression utilizing the stepwise procedure was performed in SAS to evaluate warehouse size and inbound/outbound truck movement in relation to warehouse functions. The first of theses two objectives was specifically designed to determine these relationships based upon location in eastern and western Washington. When analyzing key factors in eastern versus western Washington warehouses, there were distinct differences in the type of characteristics that impact the size and the number of inbound/outbound truckloads at a facility.

In eastern Washington, public warehouses, the number of employees, and total number of business services offered were identified as significant factors influencing inbound truckload movement. For outbound truck movement, key factors were the number of employees and those facilities offering public warehouses services. Facilities that function as public warehouses have a large number of inbound and outbound truckloads per week than any other facility type in this region.

From this analysis, it is apparent that public warehouses have a significant impact on the number of truckloads occurring within eastern Washington. To remain competitive in this industry, warehouses in this area will likely continue to look for ways to provide additional value-added services and extra manpower to meet the growing needs of their clientele. This will in turn increase the amount of inbound/outbound truck movement in the area.

For western Washington, key factors influencing the number of inbound truckloads were whether a facility offers cold storage services, the total number of business services, the number of bays and employees available, and those facilities identified as ‘Other’. A significant amount of inbound truck movement occurs at cold storage facilities. For outbound truck movement, warehouse functions shown to be significant were again ‘Other’ facilities and the total number of bays and employees. The largest number of outbound truckloads in this region is generated from facilities identified as ‘Other’. Some of these ‘Other’ facilities were described as container terminals and manufacturing facilities. Overall, cold storage facilities and ‘Other’ warehouses generate the largest number of inbound and outbound truckloads per week for this region.

When looking at facility size, warehouses in eastern Washington will typically be smaller for facilities that operate their own private fleet. In addition, as the number of bays increase, the overall square footage of a facility becomes considerably larger. Warehouses in western Washington that were identified as ‘Other’ were found to have significantly less square footage than all other facility types. These warehouses, typically container terminals and manufacturing facilities, usually do not require a large amount of space for storage. Generally, facilities that offer contract services will also be small. Furthermore, facility size in this region steadily increases as the number of employees and bays rises. Finally, western warehouses which outsource their logistics to a third-party provider were found to have a significant increase in square footage.

The third and final objective of this research was to evaluate the same three issues discussed above in relation to the warehouse functions of domestic and international warehouses. In domestic warehouses, cross-docking, the number of bays, the number of employees, the average inbound payload, and those facilities listed as ‘Other’ were all considered significant factors for inbound movement. Those facilities offering cross-docking facilities receive a significant number of inbound truckloads. In general these key functions or characteristics may indicate that domestic warehouses handle a significant amount of time-sensitive products, which are quickly received and then redistributed to other distribution/retail outlets.

For outbound truckload movement, the total number of products handled at the facility, the number of employees, and those facilities that use third-party logistic providers are considered significant factors for domestic warehouses. There is only a slight increase in the number of outbound truckloads as the number of employees at a facility increases. Domestic warehouses that handle a wide variety of products have a noticeable increase in the number of outbound truckloads per week. Meanwhile, those facilities using third-party logistic providers will have significantly fewer outbound truckloads compared to facilities that do not outsource.

Key indicators in the number of inbound truckloads arriving at international warehouses were the number of business services, bays, average inbound payload, facilities utilizing a private fleet, and those that offer cold storage facilities. Facilities offering cold storage services will have significantly more inbound truckloads per week than any other facility type. There is a small increase in truckload volume for those warehouses offering additional business services. Furthermore, warehouses operating their own private fleet apparently have fewer inbound truckloads arriving at the facility each week.

For outbound movement, factors such as the number of bays, average outbound payload, and whether a facility offers cold storage services were key factors for international warehouses. Each factor has a positive influence on the number of outbound truckloads occurring. Facilities with a larger number of bays and greater outbound payload weight have only marginal increases in the number of outbound truckloads per week. International warehouses that provide cold storage services have significantly more outbound truckloads than any other facility type.

In analyzing square footage, it appears that the size of both domestic and international warehouses is significantly influenced by the total number of bays and employees within the facility. For international warehouses, other key factors influencing square footage were those facilities considered to be ‘Other’, those that offered contract services, and warehouses operating a private fleet. As expected, facilities are much larger as the number of bays and employees increases. Those facilities that are contract or ‘Other’ warehouses are smaller than other facility types involved with trade. Warehouses that operate a private fleet to transport products to and from the facility are also smaller. Apparently the size of warehouses, particularly those involved with international trade, were not significantly influenced by such factors as total number of products handled or the number of business services offered.

Conclusion

The general scope of this research was to develop insights into the operations and freight mobility needs of the warehouse/distribution center industry in Washington. Regression analysis was used to measure warehouse functions or characteristics which have a significant influence on the square footage and the number of inbound/outbound truckloads. This analysis is intended to enhance the ability of public and private policy makers to provide for current freight transportation needs and to anticipate the infrastructure development and investment needed to maintain economic vitality of this industry in the state.

Future research should consider supplementary analysis on public warehouses and cold storage facilities in eastern and western Washington respectively. The operations of these two facility types apparently have considerable influence upon truckload movement within Washington. In addition, this study indicated that size and the number of inbound truckloads is greater for international warehouses that operate a private fleet, whereas the size of western warehouses and the number of outbound truckloads is greater for those who outsource to third-party logistics providers. Research is needed to further investigate the relationships between warehouses that operate a private fleet versus those that outsource to third-party logistic providers. Finally, research pertaining to the different commodity types handled in relation to a facility's location should also be undertaken.

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APPENDIX A

QUANTITATIVE AND QUALITATIVE MEASURES

Table A.1. Quantitative Measures of Washington's Warehouse Industry

	Warehouse Characteristics				Inbound Movement			Outbound Movement		
East	**# of Employees**	**Sq. Footage**	**Loading Bays**	**Average Length of Haul**	**# of Truckloads Inbound**	**Inbound Payload**	**Inbound Stops**	**# of Truckloads Outbound**	**Outbound Payload**	**Outbound Stops**
Min.	1.0	5000.0	1.0	18.0	1.0	400.0	1.0	1.0	300.0	1.0
Max.	360.0	700000.0	96.0	3000.0	3500.0	90000.0	10.0	705.0	64000.0	20.0
Mean	48.2	107569.8	11.1	323.7	129.0	39665.7	1.6	70.3	31581.1	6.4
Standard Deviation	81.2	160598.4	17.5	623.7	567.6	20446.1	1.7	148.0	18363.1	6.3
# of Observations	44.0	36.0	41.0	27.0	38.0	35.0	28.0	38.0	37.0	32.0
West	**# of Employees**	**Sq. Footage**	**Loading Bays**	**Average Length of Haul**	**# of Truckloads Inbound**	**Inbound Payload**	**Inbound Stops**	**# of Truckloads Outbound**	**Outbound Payload**	**Outbound Stops**
Min.	1.0	25.0	1.0	5.0	1.0	200.0	1.0	1.0	200.0	1.0
Max.	3500.0	1000000.0	250.0	3000.0	1050.0	65000.0	12.0	1050.0	3600000.0	30.0
Mean	101.6	112320.6	21.0	376.7	80.0	31605.2	2.1	98.1	93716.5	5.4
Standard Deviation	379.0	186313.7	35.1	655.3	156.5	16475.9	2.1	155.3	430715.9	6.1
# of Observations	95.0	89.0	88.0	57.0	84.0	75.0	65.0	82.0	74.0	69.0
Domestic	**# of Employees**	**Sq. Footage**	**Loading Bays**	**Average Length of Haul**	**# of Truckloads Inbound**	**Inbound Payload**	**Inbound Stops**	**# of Truckloads Outbound**	**Outbound Payload**	**Outbound Stops**
Min.	1.0	110.0	1.0	18.0	1.0	1000.0	1.0	1.0	700.0	1.0
Max.	400.0	700000.0	96.0	2500.0	460.0	70000.0	10.0	705.0	1000000.0	30.0
Mean	56.3	73070.8	11.5	239.8	42.3	34633.3	1.9	77.8	54665.2	54665.2
Standard Deviation	96.6	130359.1	18.6	456.1	91.2	20285.3	1.8	140.7	170573.9	6.9
# of Observations	47.0	45.0	42.0	31.0	39.0	33.0	30.0	39.0	33.0	34.0
International	**# of Employees**	**Sq. Footage**	**Loading Bays**	**Average Length of Haul**	**# of Truckloads Inbound**	**Inbound Payload**	**Inbound Stops**	**# of Truckloads Outbound**	**Outbound Payload**	**Outbound Stops**
Min.	1.0	25.0	1.0	5.0	1.0	200.0	1.0	1.0	200.0	1.0
Max.	3500.0	1000000.0	250.0	3000.0	3500.0	90000.0	12.0	1050.0	3600000.0	20.0
Mean	99.2	132260.8	20.9	429.8	120.1	33971.3	2.0	94.8	80763.7	5.2
Standard Deviation	383.5	198392.5	35.0	724.1	406.4	17272.4	2.1	159.0	406173.2	5.7
# of Observations	92.0	80.0	87.0	53.0	83.0	77.0	63.0	81.0	78.0	67.0
Washington State	**# of Employees**	**Sq. Footage**	**Loading Bays**	**Average Length of Haul**	**# of Truckloads Inbound**	**Inbound Payload**	**Inbound Stops**	**# of Truckloads Outbound**	**Outbound Payload**	**Outbound Stops**
Min.	1.0	25.0	1.0	5.0	1.0	200.0	1.0	1.0	200.0	1.0
Max.	3500.0	1000000.0	250.0	3000.0	3500.0	90000.0	12.0	1050.0	3600000.0	30.0
Mean	84.7	110952.4	17.8	359.7	95.3	34169.9	1.9	89.3	73004.7	5.7
Standard Deviation	317.0	178660.3	30.9	642.0	340.4	18136.0	2.0	152.9	352266.1	6.1
# of Observations	139.0	125.0	129.0	84.0	122.0	110.0	93.0	120.0	111.0	101.0

TABLE A.1. Continued

	Inbound Period of the Day					Outbound Period of the Day				
East	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	100.0	50.0	25.0	80.0	100.0	100.0	100.0	100.0	90.0
Mean %	42.1	36.0	12.3	3.0	4.2	37.9	31.5	19.0	4.5	7.0
Standard Deviation	34.9	30.8	16.3	6.6	13.2	36.3	34.2	29.9	16.3	21.2
# of Observations	42.0	42.0	42.0	42.0	42.0	41.0	41.0	41.0	41.0	41.0
West	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	85.0	100.0	75.0	50.0	80.0	100.0	100.0	100.0	100.0	100.0
Mean %	32.8	41.7	15.2	4.4	4.8	32.1	29.2	23.7	6.4	8.7
Standard Deviation	24.6	24.2	18.8	9.3	13.7	30.4	27.1	28.6	16.8	21.5
# of Observations	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Domestic	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	100.0	60.0	20.0	80.0	100.0	100.0	100.0	88.0	90.0
Mean %	34.6	39.0	15.0	2.4	4.6	43.9	22.8	17.3	5.3	10.6
Standard Deviation	31.3	29.5	18.0	5.4	14.1	35.4	27.2	25.1	16.7	22.6
# of Observations	45.0	45.0	45.0	45.0	45.0	44.0	44.0	44.0	44.0	44.0
International	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	100.0	75.0	50.0	80.0	100.0	100.0	100.0	100.0	100.0
Mean %	36.3	40.4	14.0	4.7	4.6	29.0	33.4	23.5	6.1	7.0
Standard Deviation	27.0	24.3	18.2	9.7	13.3	29.6	29.9	30.6	16.6	20.7
# of Observations	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
Washington State	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**	**6 AM - 9 AM**	**9 AM - 3 PM**	**3 PM - 6 PM**	**6 PM - 10 PM**	**10 PM - 6 AM**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	100.0	75.0	50.0	80.0	100.0	100.0	100.0	100.0	100.0
Mean %	35.7	39.9	14.3	4.0	4.6	33.9	29.9	21.5	5.8	8.2
Standard Deviation	28.4	26.4	18.1	8.6	13.5	32.3	29.3	28.9	16.6	21.3
# of Observations	135.0	135.0	135.0	135.0	135.0	134.0	134.0	134.0	134.0	134.0

TABLE A.1. Continued

	Inbound Seasonal						Outbound Seasonal					
EAST	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**
Minimum %	0.0	0.0	0.0	3.0	2.0	0.0	10.0	10.0	0.0	0.0	0.0	5.0
Maximum %	40.0	30.0	30.0	97.0	85.0	37.0	30.0	60.0	30.0	35.0	45.0	42.0
Mean %	12.4	14.4	15.9	21.8	23.3	12.3	15.9	16.6	15.9	17.8	17.9	16.0
Standard Deviation	107.2	6.7	7.4	13.8	18.8	6.5	5.7	8.1	5.8	7.5	8.4	7.0
# of Observations	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	40.0	40.0	40.0	40.0
WEST	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0	10.0	5.0
Maximum %	25.0	40.0	40.0	60.0	45.0	30.0	25.0	30.0	40.0	40.0	50.0	50.0
Mean %	12.3	14.7	18.1	20.8	19.4	13.7	13.2	14.8	17.5	19.8	19.2	15.6
Standard Deviation	4.9	5.6	6.8	7.2	7.8	5.5	4.6	4.4	7.0	5.9	7.1	7.4
# of Observations	86.0	86.0	86.0	86.0	86.0	86.0	85.0	85.0	85.0	85.0	85.0	85.0
Domestic	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**
Minimum %	0.0	0.0	0.0	3.0	0.0	0.0	10.0	10.0	5.0	0.0	0.0	5.0
Maximum %	40.0	30.0	30.0	35.0	80.0	37.0	30.0	60.0	30.0	35.0	30.0	50.0
Mean %	14.2	15.3	17.8	19.3	20.2	13.3	14.8	16.5	17.7	18.1	17.0	15.9
Standard Deviation	6.5	5.4	6.6	5.4	15.2	6.7	4.3	8.0	5.3	6.4	5.3	8.5
# of Observations	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	40.0	40.0	40.0	40.0
International	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	0.0	0.0	10.0	5.0
Maximum %	25.0	40.0	40.0	97.0	85.0	30.0	30.0	30.0	40.0	40.0	50.0	40.0
Mean %	11.5	14.2	17.2	21.9	20.8	13.2	13.7	14.8	16.7	19.6	19.6	15.6
Standard Deviation	5.0	6.2	7.3	11.1	11.0	5.5	5.5	4.5	7.2	6.5	8.3	6.7
# of Observations	86.0	86.0	86.0	86.0	86.0	86.0	85.0	85.0	85.0	85.0	85.0	85.0
Washington State	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**	**Jan - Feb**	**Mar - Apr**	**May - June**	**Jul - Aug**	**Sept - Oct**	**Nov - Dec**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	0.0	0.0	0.0	5.0
Maximum %	40.0	40.0	40.0	97.0	85.0	37.0	30.0	60.0	40.0	40.0	50.0	50.0
Mean %	12.3	14.6	17.4	21.1	20.6	13.2	14.0	15.3	17.0	19.1	18.8	15.7
Standard Deviation	5.6	5.9	7.1	9.7	12.4	5.9	5.1	5.9	6.6	6.5	7.5	7.3
# of Observations	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0

TABLE A.1. Continued

	Inbound Mode							Outbound Mode						
EAST	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	2.0	5.0	70.0	100.0	25.0	50.0	100.0	40.0	5.0	50.0	40.0	80.0	50.0
Mean %	88.5	0.1	0.4	5.0	3.8	0.9	1.2	84.8	1.4	0.6	4.0	3.0	4.7	1.5
Standard Deviation	21.5	0.4	1.4	13.8	15.7	4.1	7.7	26.5	6.5	1.6	10.2	9.8	14.2	7.9
# of Observations	42.0	42.0	42.0	42.0	42.0	42.0	42.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0
WEST	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	40.0	30.0	90.0	100.0	100.0	10.0	100.0	40.0	20.0	60.0	99.0	100.0	100.0
Mean %	69.2	1.1	1.9	5.4	5.7	16.5	0.2	77.8	1.1	1.6	2.9	4.7	10.8	1.2
Standard Deviation	34.9	5.2	4.9	15.3	15.0	29.5	1.4	31.9	4.7	3.9	8.9	15.2	25.0	10.4
# of Observations	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Domestic	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	15.0	20.0	50.0	100.0	100.0	50.0	100.0	5.0	20.0	10.0	25.0	70.0	50.0
Mean %	85.9	0.4	1.2	2.6	4.4	4.3	1.3	93.0	0.1	0.8	0.5	1.5	3.0	1.1
Standard Deviation	26.0	2.2	3.9	8.9	15.9	15.5	7.5	15.5	0.8	3.4	2.1	5.5	11.7	7.5
# of Observations	46.0	46.0	46.0	46.0	46.0	46.0	46.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0
International	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	40.0	30.0	90.0	100.0	97.0	9.0	100.0	40.0	20.0	60.0	99.0	100.0	100.0
Mean %	69.7	1.0	1.6	6.7	5.4	15.5	0.1	73.6	1.7	1.5	4.6	5.5	11.8	1.3
Standard Deviation	34.2	5.1	4.3	16.9	14.9	28.8	1.0	33.9	6.4	3.4	11.0	16.2	25.6	10.6
# of Observations	89.0	89.0	89.0	89.0	89.0	89.0	89.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
Washington State	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	40.0	30.0	90.0	100.0	100.0	50.0	100.0	40.0	20.0	60.0	99.0	100.0	100.0
Mean %	75.2	0.8	1.5	5.3	5.1	11.6	0.5	79.9	1.2	1.3	3.2	4.2	8.9	1.3
Standard Deviation	32.5	4.4	4.2	14.8	15.2	25.6	4.4	30.5	5.3	3.4	9.2	13.8	22.4	9.7
# of Observations	135.0	135.0	135.0	135.0	135.0	135.0	135.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0

TABLE A.1. Continued

	Import Mode							Export Mode						
EAST	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	10.0	1.0	25.0	90.0	100.0	0.0	100.0	10.0	5.0	20.0	10.0	100.0	0.0
Mean %	41.5	0.5	0.1	1.2	4.8	33.0	0.0	45.7	0.7	0.4	2.1	0.7	21.8	0.0
Standard Deviation	47.9	2.2	0.3	5.5	19.6	47.3	0.0	45.3	2.4	1.2	5.6	2.4	37.6	0.0
# of Observations.	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
WEST	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	10.0	50.0	90.0	100.0	100.0	10.0	100.0	100.0	100.0	80.0	20.0	100.0	100.0
Mean %	35.1	0.3	3.0	4.9	2.6	48.4	0.2	22.7	4.6	3.2	4.3	0.6	32.3	1.9
Standard Deviation	43.2	1.5	8.1	19.3	13.7	44.1	1.3	38.9	19.8	14.9	16.2	3.0	43.7	13.4
# of Observations.	55.0	55.0	55.0	55.0	55.0	55.0	55.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
Domestic	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Standard Deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
# of Observations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	10.0	50.0	90.0	100.0	100.0	10.0	100.0	100.0	100.0	80.0	20.0	100.0	100.0
Mean %	36.9	0.3	2.2	3.9	3.2	44.1	0.1	28.9	3.6	2.4	3.7	0.6	29.4	1.4
Standard Deviation	44.3	1.7	7.0	16.7	15.5	45.2	1.1	41.7	17.0	12.7	14.1	2.9	42.1	11.4
# of Observations	76.0	76.0	76.0	76.0	76.0	76.0	76.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
Washington State	**Truck**	**Barge-Truck**	**Air-Truck**	**Rail**	**Rail-Truck**	**Ocean-Truck**	**Other**	**Truck**	**Truck-Barge**	**Truck-Air**	**Rail**	**Truck-Rail**	**Truck-Ocean**	**Other**
Minimum %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum %	100.0	10.0	50.0	90.0	100.0	100.0	10.0	100.0	100.0	100.0	80.0	20.0	100.0	100.0
Mean %	36.9	0.3	2.2	3.9	3.2	44.1	0.1	28.9	3.6	2.4	3.7	0.6	29.4	1.4
Standard Deviation	44.3	1.7	7.0	16.7	15.5	45.2	1.1	41.7	17.0	12.7	14.1	2.9	42.1	11.4
# of Observations	76.0	76.0	76.0	76.0	76.0	76.0	76.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0

TABLE A.2. Qualitative Measures of Washington's Warehouse Industry

	Hours of Operation				Days of Operation				Cross Docking	Fleet Type		
East	**8 a.m.-5 p.m.**	**Before 8 a.m.**	**After 5 p.m.**	**24 hours**	**Mon.-Fri.**	**Mon.-Sat.**	**Mon-Sun.**	**Sun.-Fri.**	**Yes**	**Private Fleet**	**3PL**	**Both**
Count	41	29	17	3	25	8	5	3	12	13	14	15
Total Observations	42	42	42	42	41	41	41	41	44	42	42	42
Percentage	97.6%	69.0%	40.5%	7.1%	61.0%	19.5%	12.2%	7.3%	27.3%	31.0%	33.3%	35.7%
West	**8 a.m.-5 p.m.**	**Before 8 a.m.**	**After 5 p.m.**	**24 hours**	**Mon.-Fri.**	**Mon.-Sat.**	**Mon-Sun.**	**Sun.-Fri.**	**Yes**	**Private Fleet**	**3PL**	**Both**
Count	96	73	43	14	75	3	14	2	51	27	38	27
Total Observations	96	96	96	96	94	94	94	94	97	92	92	92
Percentage	100.0%	76.0%	44.8%	14.6%	79.8%	3.2%	14.9%	2.1%	52.6%	29.3%	41.3%	29.3%
Domestic	**8 a.m.-5 p.m.**	**Before 8 a.m.**	**After 5 p.m.**	**24 hours**	**Mon.-Fri.**	**Mon.-Sat.**	**Mon-Sun.**	**Sun.-Fri.**	**Yes**	**Private Fleet**	**3PL**	**Both**
Count	46	33	23	4	29	8	9	2	11	24	5	16
Total Observations	47	47	47	47	48	48	48	48	48	45	45	45
Percentage	97.9%	70.2%	48.9%	8.5%	60.4%	16.7%	18.8%	4.2%	22.9%	53.3%	11.1%	35.6%
International	**8 a.m.-5 p.m.**	**Before 8 a.m.**	**After 5 p.m.**	**24 hours**	**Mon.-Fri.**	**Mon.-Sat.**	**Mon-Sun.**	**Sun.-Fri.**	**Yes**	**Private Fleet**	**3PL**	**Both**
Count	91	69	37	14	71	3	10	3	52	16	47	26
Total Observations	93	93	93	93	87	87	87	87	93	89	89	89
Percentage	97.8%	74.2%	39.8%	15.1%	81.6%	3.4%	11.5%	3.4%	55.9%	18.0%	52.8%	29.2%
Washington State	**8 a.m.-5 p.m.**	**Before 8 a.m.**	**After 5 p.m.**	**24 hours**	**Mon.-Fri.**	**Mon.-Sat.**	**Mon-Sun.**	**Sun.-Fri.**	**Yes**	**Private Fleet**	**3PL**	**Both**
Count	137	102	60	17	100	11	19	5	63	40	52	42
Total Observations	138	138	138	138	135	135	135	135	141	134	134	134
Percentage	99.3%	73.9%	43.5%	12.3%	74.1%	8.1%	14.1%	3.7%	44.7%	29.9%	38.8%	31.3%

TABLE A.2. Continued

	Business Services						Inventory Control Program			Mode Capabilities						
East	**Assembly/ Consolidation**	**Pool Distribution**	**Pick & Pack**	**Labeling**	**Ticketing**	**Other**	**EDI**	**JIT**	**Other**	**None**	**Air**	**Rail**	**Truck**	**Ocean**	**Barge**	**Other**
Count	9	4	9	9	3	8	14	7	17	0	7	17	41	7	3	2
Total Observations	26	26	26	26	26	26	33	33	33	42	42	42	42	42	42	42
Percentage	34.6%	15.4%	34.6%	34.6%	11.5%	30.8%	42.4%	21.2%	51.5%	0.00%	16.67%	40.48%	97.62%	16.67%	7.14%	4.76%
West	**Assembly/ Consolidation**	**Pool Distribution**	**Pick & Pack**	**Labeling**	**Ticketing**	**Other**	**EDI**	**JIT**	**Other**	**None**	**Air**	**Rail**	**Truck**	**Ocean**	**Barge**	**Other**
Count	36	11	34	30	11	11	30	21	34	1	21	37	94	34	12	3
Total Observations	65	65	65	65	65	65	74	74	74	95	95	95	95	95	95	95
Percentage	55.4%	16.9%	52.3%	46.2%	16.9%	16.9%	40.5%	28.4%	45.9%	1.05%	22.11%	38.95%	98.95%	35.79%	12.63%	3.16%
Domestic	**Assembly/ Consolidation**	**Pool Distribution**	**Pick & Pack**	**Labeling**	**Ticketing**	**Other**	**EDI**	**JIT**	**Other**	**None**	**Air**	**Rail**	**Truck**	**Ocean**	**Barge**	**Other**
Count	7	5	7	6	1	8	10	6	19	1	4	11	44	4	0	1
Total Observations	25	25	25	25	25	25	29	29	29	46	46	46	46	46	46	46
Percentage	28.0%	20.0%	28.0%	24.0%	4.0%	32.0%	34.5%	20.7%	65.5%	2.17%	8.70%	23.91%	95.65%	8.70%	0.00%	2.17%
International	**Assembly/ Consolidation**	**Pool Distribution**	**Pick & Pack**	**Labeling**	**Ticketing**	**Other**	**EDI**	**JIT**	**Other**	**None**	**Air**	**Rail**	**Truck**	**Ocean**	**Barge**	**Other**
Count	38	10	36	33	13	11	34	22	32	0	24	43	91	37	15	4
Total Observations	69	69	69	69	69	69	78	78	78	91	91	91	91	91	91	91
Percentage	55.1%	14.5%	52.2%	47.8%	18.8%	15.9%	43.6%	28.2%	41.0%	0.00%	26.37%	47.25%	100.00%	40.66%	16.48%	4.40%
Washington State	**Assembly/ Consolidation**	**Pool Distribution**	**Pick & Pack**	**Labeling**	**Ticketing**	**Other**	**EDI**	**JIT**	**Other**	**None**	**Air**	**Rail**	**Truck**	**Ocean**	**Barge**	**Other**
Count	45	15	43	39	14	19	44	28	51	1	28	54	135	41	15	5
Total Observations	91	91	91	91	91	91	107	107	107	137	137	137	137	137	137	137
Percentage	49.5%	16.5%	47.3%	42.9%	15.4%	20.9%	41.1%	26.2%	47.7%	0.73%	20.44%	39.42%	98.54%	29.93%	10.95%	3.65%

TABLE A.2. Continued

	Product Type										
East	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber**	**General Merchandise**	**Food & Grocery**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Other**
Count	7	11	11	2	7	7	15	5	8	4	16
Total Observations	44	44	44	44	44	44	44	44	44	44	44
Percentage	15.9%	25.0%	25.0%	4.5%	15.9%	15.9%	34.1%	11.4%	18.2%	9.1%	36.4%
West	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber**	**General Merchandise**	**Food & Grocery**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Other**
Count	20	24	23	2	34	43	26	3	26	13	30
Total Observations	97	97	97	97	97	97	97	97	97	97	97
Percentage	20.6%	24.7%	23.7%	2.1%	35.1%	44.3%	26.8%	3.1%	26.8%	13.4%	30.9%
Domestic	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber**	**General Merchandise**	**Food & Grocery**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Other**
Count	8	8	14	2	11	11	12	2	12	5	20
Total Observations	48	48	48	48	48	48	48	48	48	48	48
Percentage	16.7%	16.7%	29.2%	4.2%	22.9%	22.9%	25.0%	4.2%	25.0%	10.4%	41.7%
International	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber**	**General Merchandise**	**Food & Grocery**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Other**
Count	19	27	20	2	30	39	29	6	22	12	26
Total Observations	93	93	93	93	93	93	93	93	93	93	93
Percentage	20.4%	29.0%	21.5%	2.2%	32.3%	41.9%	31.2%	6.5%	23.7%	12.9%	28.0%
Washington State	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber**	**General Merchandise**	**Food & Grocery**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Other**
Count	27	35	34	4	41	50	41	8	34	17	46
Total Observations	141	141	141	141	141	141	141	141	141	141	141
Percentage	19.1%	24.8%	24.1%	2.8%	29.1%	35.5%	29.1%	5.7%	24.1%	12.1%	32.6%

TABLE A.2. Continued

	Import Countries									Export Countries								
East	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**
Count	11	1	5	0	1	2	2	6	7	12	3	8	5	7	5	7	8	4
Total Observations	17	17	17	17	17	17	17	17	17	15	15	15	15	15	15	15	15	15
Percentage	64.71%	5.88%	29.41%	0.00%	5.88%	11.76%	11.76%	35.29%	41.18%	80.00%	20.00%	53.33%	33.33%	46.67%	33.33%	46.67%	53.33%	26.67%
West	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**
Count	37	19	16	16	24	15	30	40	13	22	16	6	9	25	6	18	19	12
Total Observations	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Percentage	61.67%	31.67%	26.67%	26.67%	40.00%	25.00%	50.00%	66.67%	21.67%	36.67%	26.67%	10.00%	15.00%	41.67%	10.00%	30.00%	31.67%	20.00%
Domestic	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**
Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Observations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percentage	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
International	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**
Count	48	20	21	16	25	17	32	46	20	34	19	14	14	32	11	25	27	16
Total Observations	77	77	77	77	77	77	77	77	77	75	75	75	75	75	75	75	75	75
Percentage	62.34%	25.97%	27.27%	20.78%	32.47%	22.08%	41.56%	59.74%	25.97%	45.33%	25.33%	18.67%	18.67%	42.67%	14.67%	33.33%	36.00%	21.33%
Washington State	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**	**Canada**	**S. Korea**	**Mexico**	**Philippines**	**Japan**	**Malaysia**	**Taiwan**	**China**	**Other**
Count	48	20	21	16	25	17	32	46	20	34	19	14	14	32	11	25	27	16
Total Observations	77	77	77	77	77	77	77	77	77	75	75	75	75	75	75	75	75	75
Percentage	62.34%	25.97%	27.27%	20.78%	32.47%	22.08%	41.56%	59.74%	25.97%	45.33%	25.33%	18.67%	18.67%	42.67%	14.67%	33.33%	36.00%	21.33%

TABLE A.2. Continued

	Import Products										
East	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber Products**	**General Merchandise**	**Food & Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	2	4	5	0	3	1	2	1	6	0	2
Total Observations	18	18	18	18	18	18	18	18	18	18	18
Percentage	11.11%	22.22%	27.78%	0.00%	16.67%	5.56%	11.11%	5.56%	33.33%	0.00%	11.11%
West	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber Products**	**General Merchandise**	**Food & Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	4	8	8	1	12	32	17	0	12	6	18
Total Observations	60	60	60	60	60	60	60	60	60	60	60
Percentage	6.67%	13.33%	13.33%	1.67%	20.00%	53.33%	28.33%	0.00%	20.00%	10.00%	30.00%
Domestic	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber Products**	**General Merchandise**	**Food & Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	0	0	0	0	0	0	0	0	0	0	0
Total Observations	0	0	0	0	0	0	0	0	0	0	0
Percentage	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
International	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber Products**	**General Merchandise**	**Food & Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	6	12	13	1	15	33	19	1	18	6	20
Total Observations	78	78	78	78	78	78	78	78	78	78	78
Percentage	7.69%	15.38%	16.67%	1.28%	19.23%	42.31%	24.36%	1.28%	23.08%	7.69%	25.64%
Washington State	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper & Lumber Products**	**General Merchandise**	**Food & Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	6	12	13	1	15	33	19	1	18	6	20
Total Observations	78	78	78	78	78	78	78	78	78	78	78
Percentage	7.69%	15.38%	16.67%	1.28%	19.23%	42.31%	24.36%	1.28%	23.08%	7.69%	25.64%

TABLE A.2. Continued

					Export Products						
East	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper and Lumber Products**	**General Merchandise**	**Food and Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	0	5	2	0	1	1	2	0	3	2	4
Total Observations	15	15	15	15	15	15	15	15	15	15	15
Percentage	0.00%	33.33%	13.33%	0.00%	6.67%	6.67%	13.33%	0.00%	20.00%	13.33%	26.67%
West	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper and Lumber Products**	**General Merchandise**	**Food and Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	7	13	4	1	17	18	15	1	10	5	12
Total Observations	60	60	60	60	60	60	60	60	60	60	60
Percentage	11.67%	21.67%	6.67%	1.67%	28.33%	30.00%	25.00%	1.67%	16.67%	8.33%	20.00%
Domestic	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper and Lumber Products**	**General Merchandise**	**Food and Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	0	0	0	0	0	0	0	0	0	0	0
Total Observations	0	0	0	0	0	0	0	0	0	0	0
Percentage	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
International	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper and Lumber Products**	**General Merchandise**	**Food and Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	7	18	6	1	18	19	17	1	13	7	16
Total Observations	75	75	75	75	75	75	75	75	75	75	75
Percentage	9.33%	24.00%	8.00%	1.33%	24.00%	25.33%	22.67%	1.33%	17.33%	9.33%	21.33%
Washington State	**Hazardous Material**	**Frozen Foods**	**Beverages**	**Pharmaceutical**	**Paper and Lumber Products**	**General Merchandise**	**Food and Grocery Products**	**Agricultural Chemicals**	**Industrial Products**	**Automotive Parts**	**Others**
Count	7	18	6	1	18	19	17	1	13	7	16
Total Observations	75	75	75	75	75	75	75	75	75	75	75
Percentage	9.33%	24.00%	8.00%	1.33%	24.00%	25.33%	22.67%	1.33%	17.33%	9.33%	21.33%