EMPIRICAL ESTIMATION OF ATTRIBUTES INFLUENCING WAREHOUSE/DISTRIBUTION CENTER OPERATIONS: WASHINGTON STATE WAREHOUSE INDUSTRY

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Abstract

An estimated 21.6 million truck trips are made each year on Washington state highways. An estimated 45% of that 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 paper 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.

A survey of warehouses in the state yielded information from 142 firms broadly distributed across the state. A multiple linear regression utilizing the stepwise function is performed in SAS to evaluate, among others, the relationships among warehouse size, and inbound and outbound truck movement relative to warehouse functions. Findings include the fact 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 that 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 employees within a facility. Variations by commodity being handled are analyzed in the paper as well.

Introduction

The growing amount of congestion in the United States has prompted concerns regarding the nation and region's ability to appropriately anticipate and provide for current and future freight transportation infrastructure to improve freight mobility. In the State of Washington an estimated 21.6 million truck trips are made each year on state highways, according to a recent report by the Strategic Freight Transportation Analysis Program (SFTA). 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 was determined 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 seek to understand the complex operations and mode capabilities utilized within the warehouse/distribution center industry. The impact of this industry on the need for infrastructure development and investment within the state is generally understood but not in the detail that policy makers might find useful. The characteristics of individual warehouse/distribution centers that are associated with increases in demand for transportation infrastructure would be of special interest as these investments are made. Little specific data are available on the operational and transportation structure of these warehouses, nationally and certainly in the State of Washington.

It can be expected that various operating attributes, such as the facility or firm's hourly time of operation and attendant shipment patterns during the day, the different commodities being handled, the various business services offered, the average payload, etc., will affect the needs for transportation infrastructure for that new or existing facility. Differing demands to service international trade movements versus solely domestic movements may also exist. As different regions within a state specialize in becoming hubs of warehousing an understanding of these characteristics becomes even more necessary for planning and service purposes.

Study Objectives

The general purpose of this study was to determine the operations and transportation usage of warehouse/distribution centers in The State of Washington. Three specific objectives were used to achieve the general purpose: 1) Review the common operations and functions performed in the warehouse/ distribution center industry in Washington, 2) Determine the relationship of warehouse size, and inbound and outbound truck movement, as variables associated with transportation demand, relative to facility location. Warehouses in the state of Washington were sorted to reflect the international, high density and high service industry on the west side of the state as contrasted to the agricultural, low traffic density and domestic service function common to the east section of the state, and 3) Evaluate the same three transportation demand issues, size and inbound and outbound truck shipment frequency, as they are affected by the firm's participation in international versus domestic trade.(For more detailed findings relative to these objectives, see Pike et al, 2005 and Pike et al, 2004)

General Warehouse Functions, Operations and Types

Warehouse and distribution centers can be generally described by functions, operations and types. 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.

The three most basic functions of a warehouse are receiving, storage, and shipping. 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 in servicing retailers, maintain large quantities to handle fluctuating demand in a market.

A company will also offer a variety of products which are produced at different plants. Product mixing, as a function, allows customers to effectively order from multiple product lines at once. The warehouse/distribution center serves as a primary assembly point for these various products. This function also decreases the number of facility locations needed to fulfill the individual customer's 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. Consolidation also allows the warehouse to make fewer truck trips with more stops to numerous destinations. The fourth function, distribution, is essentially the opposite of consolidation but offers similar efficiencies.

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 internal cost to either the warehouse or customer. However, a general justification for maintaining inventory is that if the warehouse is able to provide the desired goods in close proximity to the customer, this yields greater customer satisfaction, leading to future sales (Coyle, 1976).

Generally, there are typically six major activities associated with warehouse operations: receiving, transfer, and 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. 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 operations of 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).

Warehouses can also be categorized as to the variety of facility types performing numerous roles in the distribution of goods: 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 firm engaged in the business of storing goods for a fee. 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).

Data and Analytical Approach

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 returned useable survey responses, broadly geographically dispersed through the state.

The list of surveyed firms used in this study was compiled from sources including numerous agencies at 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. 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 (Ivanov, 2004).

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.

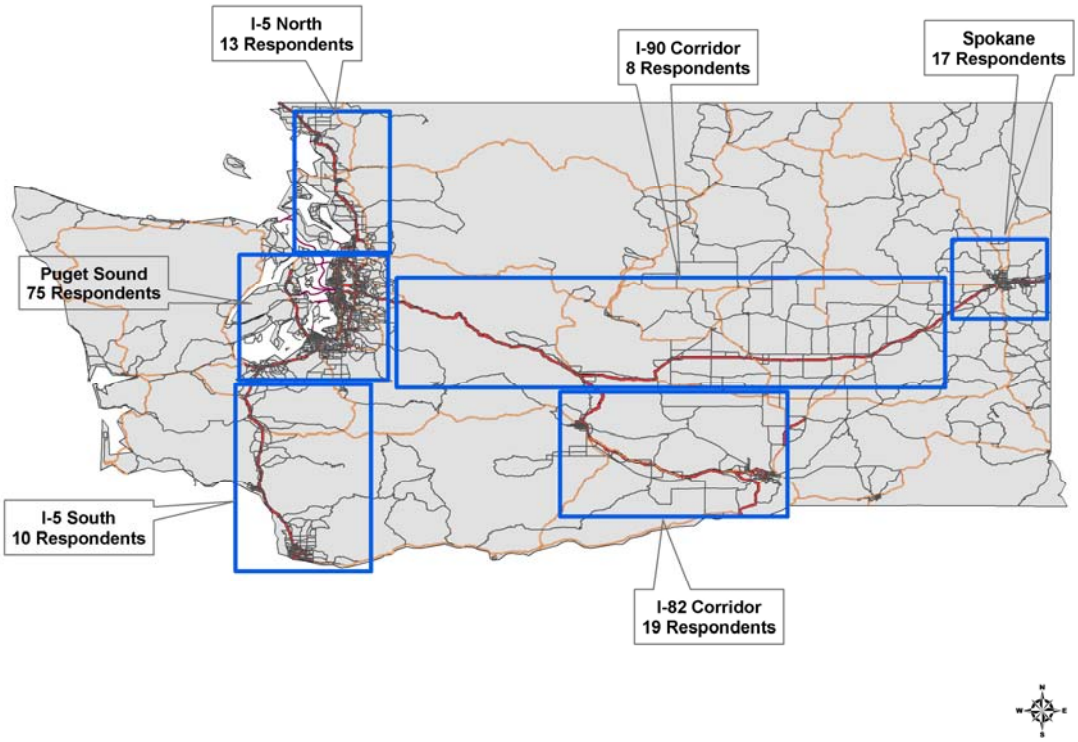

Figure 1.1. Sample Geographic Coverage Areas

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.

Inpay describes the average inbound payload weight per load. Outpay describes the average outbound payload weight per load. These two variables were included since the size of the payload per vehicle has an impact on the roadway infrastructure. 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 logistics provider to distribute its goods.

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, 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 slightly depending on the dependent variable being analyzed. A summary list of the independent variables used in each of the three models is provided with a unit indicator and description in Table 1. Note that a numeral unit is any quantitative measure starting from zero.

Table 1. Variables used in Analysis

Variable	Unit	Description
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

Outpay	Numeral	Average outbound payload weight per load
Instops	Numeral	Total number of stops made on the way to facility
Outstops	Numeral	Total number of stops made on the way from 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

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 firms 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 (Figure 1). 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.

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 function method, was used to run the regression models within SAS. 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 consider any multicollinearity between variables within the model.

Study Results

Inbound truckloads

The number of inbound trucks, as an indicator of transportation infrastructure usage, was the first focus. All variables were considered in the first model but for the total state only four variables were found significant (Table 2). Significance for this exploratory analysis was set at 0.85. The dominant variable affecting number of inbound truckloads was Cold, indicating that if a firm was a cold storage warehouse, the truckloads increased by slightly over 64 per week. Privflt, which identified a firm operating a private trucking fleet, caused the number of truckloads per week to decrease by 26.5 truckloads. The number of business services offered increased the truckloads per week by almost 11. The number of bays was positively related to the number of truckloads but the relationship was weak, less than one truckload per week.

Table 2. Inbound Truckloads

All Washington		Eastern Washington		Western Washington	
Variable	Parameter Estimate	Variable	Parameter Estimate	Variable	Parameter Estimate
Intercept	14.29	Intercept	-41.00	Intercept	-14.91
Bays	0.897	Employ	0.879	Employ	-0.046
Privflt	-26.53	Busnum	20.49	Bays	1.506
Busnum	10.72	Public	64.69	Modenum	12.11
Cold	64.32	R^2	0.577	Cold	70.97
R^2	0.342			Ofactype	28.21
				R^2	0.348

In eastern Washington, the number of employees, business services offered, and status as a public warehouse all had positive relationships with truckload traffic volume, especially status as a public warehouse which increased the number of inbound truckloads by almost 65 loads per week. These three variables explained 58% of the variation in truckloads, as indicated by the R^2 of 0.577. In western Washington the variables of significance were different, with only number of employees being common to both east and west firms, and being rather weak in effect in both areas. Being a cold storage facility in the west had a positive effect, 71 truckloads per week, while number of modes available at the location and an “other” type of facility had 12 and 28 truckloads per week positive effect. This model, with an R^2 of 0.348, was not as effective in explaining the variation in truckloads per week as the eastern Washington model.

It can be noted that the only variable common to both east and west models was employees and the coefficient was very small. Public warehouse status had a strong effect, but only in eastern Washington. Interestingly, the number of business services was important in the east and total Washington while being a cold storage facility was very important in the west and the total Washington model. The only facility type with notable effect on inbound traffic levels was the “other” category in the western Washington model.

It was also expected that operating characteristics for firm involved in international trade might be different than those in domestic movements. Analysis indicated that five variables affected inbound traffic levels in both the international and domestic models, but only two, number of bays and weight of inbound payload, were common to both models and both were low in impact, as indicated by the slope coefficient (Table 3).

Table 3. Inbound Truckloads

Domestic Warehouse			International Warehouse	
Variable	Parameter Estimate		Variable	Parameter Estimate
Intercept	7.737		Intercept	-21.46
Employ	0.534		Bays	0.864
Bays	2.617		Privflt	-35.02
Cdock	16.94		Inpay	0.0007
Inpay	-0.0004		Busnum	14.64
Ofactype	-14.30		Cold	77.40
R^2	0.8346		R^2	0.35

The “other” facility type had a negative effect, 14 truckloads per week, in the domestic model while providing cross dock services was associated with an increase of almost 17 truckloads per week (the only time this variable was significant in any of the models). These five variables in this model explained almost 84 of the variation in inbound truckloads per week.

Two variables had strong effects, negative and positive, on the level of inbound truckloads in the international model. Use of a private fleet caused a decrease in truckloads of 35 per week while being a cold storage facility is associated with an increase of 77 truckloads per week. The cold storage characteristic was very strong in both domestic and international models. The R^2 for the international model dropped significantly from the domestic model, with only 35% of the variation being explained by these variables, probably revealing the complexity of the warehouse activities in the international and western part of the state.

Outbound truckloads

The level of traffic of outbound movements was also analyzed by location in the state. For the state in total, only three variables were significant, with an R^2 for the model of 45% (table 4). Cold storage had a strong positive effect, about 46 truckloads per week, while using the third party logistics firm for transportation was associated with less volume, about 33 truckloads per week.

Table 4. Outbound Truckloads

All Washington			Eastern Washington			Western Washington	
Variable	Parameter Estimate		Variable	Parameter Estimate		Variable	Parameter Estimate
Intercept	38.21		Intercept	-15.73		Intercept	20.87
Bays	3.410		Employ	1.299		Employ	0.054
Threepl	-33.26		Public	102.7		Bays	2.234
Cold	45.84		R^2	0.58		Ofactype	42.66
R^2	0.45					R^2	0.59

In eastern Washington only two variables were significant and only one, serving as a public warehouse, had a strong impact on truckload levels where an increase of almost 103 truckloads per week was indicated. The “other” type of facility classification was the only strong variable, with almost 43 truckloads per week increase being associated with this type of facility. Both the eastern and western models explained almost two thirds of the variation in volume, even with only two and three variables being significant. The strength of the models came mainly from “other” type of facility in the west and serving as a public warehouse in the east.

Outbound traffic levels also vary differently depending on whether the facility is engaged in domestic or international trade (Table 5). Movement volume was significantly affected by three variables in both models, but no variable was common to both models. Use of third party logistical firms had a strong negative association with outbound movements, over 71 truckloads per week, indicating that smaller volume firms were the users of this type of transportation scheduling. As the number of products handled by the firm increased, the level of traffic was increased by over 37 truckloads per week in domestic oriented firms. Overall, this model explained 75% of the variation in truckload volume outbound.

Table 5. Outbound Truckloads

Domestic Warehouse			International Warehouse	
Variable	Parameter Estimate		Variable	Parameter Estimate
Intercept	-24.15		Intercept	-1.975
Employ	1.272		Bays	2.958
Threepl	-71.54		Outpay	0.0003
Prodnum	37.35		Cold	78.82
R^2	0.75		R^2	0.566

Of the three variables significant in the international model, only being a cold storage facility strongly affected the shipment levels, increasing it about 79 truckloads per week. The number of bays and the weight of the outbound

payload had only modest impacts. This model was a bit less successful overall than the domestic model, since it explained only 57% of the variation, as contrasted to 75% for the domestic model.

The inbound and outbound movements were different to some degree in the domestic versus international movements, with a lot of difference in which variables were found to be significant. Cold storage facilities were significant in both inbound and outbound movements while using a third party logistics firm was negatively strong in outbound movements but not significant in inbound. Private transportation had a strong negative effect on inbound movements but no significant effect on outbound shipment volumes. Interestingly, the R^2 was higher in both domestic models than in the international models, 75% and 83% in domestic outbound and inbound, respectively.

Size (square footage) of warehouse

Attention was paid to the relationship of size of the warehouse/distribution center, as indicated by square footage of the facility, and the operational characteristics of the firms. Both location and participation in the international market versus domestic market were investigated.

For all the firms in the study throughout the State of Washington five variables were significantly related to firm size (Table 6). Firms serving as contract warehouses (offering personal service as well as partial public availability) and "other" facility types were negatively associated with size of facility, where contract firms had over 38,000 fewer square feet and "other" firms had almost 35,000 square feet smaller facilities. Further, if a firm provided its own transportation with a private fleet, its facility was almost 44,000 square feet smaller. The number of bays and employees had modest but positive impacts on facility size.

In eastern Washington only two variables were significant. If a firm operated its own private fleet, the size of the warehouse was decreased by almost 92,000 square feet. As the number of bays increased, the square footage also increased by over 7,000 square feet in eastern Washington.

Table 6. Size (Square Footage) of Warehouse

All Washington			Eastern Washington			Western Washington	
Variable	Parameter Estimate		Variable	Parameter Estimate		Variable	Parameter Estimate
Intercept	64,408		Intercept	81,444		Intercept	15,755
Contract	-38,177		Bays	7,322.4		Contract	-47,700
Ofactype	-34,667		Privflt	-91,786		Ofactype	-53,991
Employ	121.39		R^2	0.81		Employ	119.71

Bays	4,341.6					Bays	4,151.7
Privflt	-43,881					Threepl	2,959.3
R^2	0.794					R^2	0.842

In western Washington the significant variables were, with the exception of third party logistics firms versus private fleet, the same as that of the total for the state. Serving as a contract facility or as an "other" facility type was strongly negatively related to firm size. The other three characteristics were positively but marginally related to firm size. All three models had good explanatory power, as evidenced by R^2s accounting for about 80% of the variation.

The number of bays was significant and positive in all three models, though not a strong impact per bay. Interestingly, private fleet usage was a very strong negative in eastern Washington and the use of third party logistics firms was modest, but positive, in effect in western Washington.

The domestic and international warehouse models both had number of employees and bays as significant variables (Table 7). The international warehouse model also included three other variables of significance: contract, "other" type of facility and private fleet. All three of the latter variables were strongly negatively associated with size of warehouse. In the analysis of size of warehouse analysis, as contrasted to the inbound and outbound movements, the international model explained more of the variation than did the domestic model, as measured by $R^{2.}$

Table 7. Size (Square Footage) of Warehouse

Domestic Warehouse			International Warehouse	
Variable	Parameter Estimate		Variable	Parameter Estimate
Intercept	-381.16		Intercept	74,518
Employ	486.13		Contract	-58,010
Bays	3,211.40		Ofactype	-52,937
R^2	0.694		Employ	117.06
			Bays	4,360.6
			Privflt	-45,167
			R^2	0.822

Other relationships

Only one variable chosen for this analysis was not significant in any of the analysis, the number of stops before or after leaving the facility. Payload weight was only significant for inbound in the domestic and international models but not at all in location. For outbound movements payload weight was only noted in international movements.

Private fleet usage by the firm was significant in four models and was negatively related every time to the size or volume dependent variables. The use of third party logistics firms was significant, and negative, for outbound domestic traffic but was slightly positively related to size in western Washington.

Conclusions

Congestion in, and overall capacity of, the total transportation system is becoming critical throughout the nation. Both issues are directly affected by the volume of freight traffic inbound and outbound from warehouse and distribution centers, as well as e.g. other manufacturing, processing, consolidation, etc. firms.

This study used as dependent variables the size of firm and the number of inbound and outbound truckloads to determine the characteristics of warehouses that are related to those dependent variables, variables that are directly related to the congestion and capacity issues.

This initial evaluation of a fairly massive data set (142 warehouse/distribution centers in the state of Washington) did provide increased understanding and information that will be useful for departments of transportation, planners and other policy makers. We also found that more detailed analyses, based on this preliminary investigation, will be useful and possible with this data set.

Operational characteristics did vary by location in the state and whether the firm was involved in international trade. Several individual findings were apparent. Serving as a cold storage facility had, in most of the models, a significant and strong impact on inbound and outbound traffic levels. So, if a new cold storage facility is located in an area, planners can expect a noticeable increase in traffic, in both directions from the facility. Similarly, the number of employees at a site also is positively related to, especially for inbound, the volume of truckloads. If a facility chooses to use its own fleet of trucks, this is associated with a lower number of truckloads for inbound movements.

For outbound movements, serving as a cold storage facility again has a positive effect on the level of traffic. If the facility is operated as a public warehouse, that also will have a positive effect on the level of outbound movements, notable in eastern Washington in this study. When the facility relies on third party logistics firms this is associated with a lower level of movements; hence, it appears the smaller firm may be more reliant on outside help for its logistics rather than

developing its own fleet, particularly for those firms that only work in domestic markets

When examining the size of firm, use of a private fleet is associated with a smaller facility, somewhat conflicting with the findings above. Similar conflicts exist for the use of third party logistics firms where such usage is positively associated with size of facility, unlike above where it was negatively related to traffic movement volume. This might be explained by the different functions performed by the warehouse, some of which have large space requirements and some that do not, or have difficult transportation problems, issues to be further examined with this data set.

It was surprising that cold storage status, so prevalent in the analysis of inbound and outbound traffic levels, was not significantly related to the size of facility in any of the size models. This is as well an issue to be further investigated.

Improved understanding of the differing operational characteristics of the warehouse/distribution center industry in the state of Washington resulted from this study. As indicated earlier in this article, the reader/researcher is encouraged to go to other reports by these authors, too detailed to incorporate here, for further data analysis and understanding.

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