Trucking Industry Demand for Urban Shared Use Freight Terminals

Amelia C. Regan

Department of Civil and Environmental Engineering and
Institute of Transportation Studies
University of California
Irvine, CA 92697
aregan@uci.edu

Thomas F. Golob

Institute of Transportation Studies
University of California
Irvine, CA 92697
tgolob@uci.edu

Abstract

The issue of shared use urban freight facilities first received attention during the 1970's when it was observed that, while inter-urban freight movements were becoming increasingly efficient, there were significant diseconomies in the movement of freight via truck within urban areas. Early research suggested that shared urban freight facilities should be constructed so that trucking companies could consolidate smaller shipments into larger ones. In the past few years, the concept of "Urban Ports" has gained increasing attention, not just for carriers who need to load and unload freight, but to provide a place near the urban center for truckers to wait out peak traffic periods. In this paper, using recently developed survey data, we examine trucking company interest in such facilities by examining the results of an ordered probit demand model.

Key words City logistics, Shared use freight facilities, Trucking operations, Urban ports

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Introduction

Transport engineers, planners and economists have long realized that future increases in surface transportation capacity would result less from the construction of physical transportation infrastructure than from the development of techniques and tools aimed at improving the efficient use of existing infrastructure. An efficient freight transportation system is the backbone of a successful economy. Both businesses and consumers rely every day on inexpensive and efficient goods movement. However, goods movement, particularly in urban areas, comes at a high cost to society. Large trucks mixing with congested urban passenger and pedestrian traffic are responsible for significant safety and environmental hazards and can make driving and walking very unpleasant for urban residents.

The past several years has witnessed a significant increase in public sector involvement in the freight transportation sector. Realizing that regional economic strength is dependent on swift and efficient goods movements, federal, state and local agencies are participating more regularly in infrastructure and information technology initiatives. One example is the Alameda Corridor project, a 20-mile grade-separated cargo link between the ports of Long Beach and Los Angeles, and transcontinental rail yards located near downtown Los Angeles. Another example is the HELP (Heavy Vehicle Electronic License Plate) project, a non-profit partnership between motor carriers and government agencies in nine western states (SAIC, 1994). The advantages of carefully executed public agency involvement in commercial vehicle operations are numerous.

Of current interest is the question of whether there may be a public role in the development of shared urban freight facilities. These facilities would serve several purposes. The first of these is to allow commercial vehicle operators a place to wait near the urban center so that they can drive a large portion of their trip in off peak hours. Commercial vehicle operators are often constrained by schedules that force them to make deliveries during the morning or afternoon peak hours. Reducing some of their peak period travel would benefit both the truckers and the public. The second purpose of the shared urban freight facilities would be to serve as a meeting point where loads could be broken out of large vehicles into several smaller combinations. There might be opportunities for companies to make urban pickups and deliveries with smaller vehicles without purchasing and managing prohibitively expensive urban warehouse space. Or, Less than truckload (LTL) carriers might find consolidation opportunities. Another purpose of these facilities would be to provide a place where truckers can rest safely before or after the stressful urban leg of their trips. Lastly, these facilities would be equipped with information technologies that allow commercial vehicle operators to communicate easily with their home offices and to gain access to the most up to date real-time traffic network information available.

Background

The issue of shared use urban freight facilities first received significant attention during the 1970's when it was observed that, while inter-urban freight movements had become much more efficient, significant diseconomies characterized the movement of truck freight within urban areas (Clark and Ashton, 1977, Friedman, 1975). Most of that research suggested that shared urban freight facilities should be constructed so that freight companies could consolidate smaller shipments into larger ones. However, a sharp reduction in average shipment sizes, fueled by the growth in just-in-time manufacturing and distribution systems, dynamic management of inventories and e-commerce initiatives suggest that today's shared urban freight facilities will be de-consolidation centers where large deliveries are transferred to smaller vehicles for the final leg of their trips. The kinds of facilities identified by Friedman and Clark and Ashton failed to materialize, because it was judged that development and operating costs would exceed what carriers would be willing to pay.

More recently, Taniguchi et al (1999) state that public logistics terminals may help alleviate traffic congestion, reduce negative environmental impacts and decrease energy consumption. In response to Japanese public sector interest in the development of such terminals, those researchers developed an optimization model to assist with the location and sizing of such terminals. Taniguchi and Van Der Heijden (2000) mention public logistics terminals as one method for increasing cooperation in freight transportation systems. Their model suggests that cooperative freight systems reduce carbon dioxide emissions as well as the distance traveled by trucks. The European Union conducted some experiments on methods of increasing the efficiency of urban distribution and reducing environmental impacts through the Sustainable Urban and Regional Freight Flows (SURFF, 1998) program. Various policies were implemented in seven test sites. The Stockholm test site focused mainly on city logistics including coordinating deliveries. Simulations of coordinated urban distribution showed improvements over the current system. Overall, the SURFF test sites indicated that modifying transport, warehousing and logistics processes usually decreased negative environmental impacts. In addition, roughly a 20% reduction in vehicle-kilometers traveled was made possible by the use of load consolidation and route planning applications. Weisbrod *et al*, 2002 provide the most comprehensive study of the feasibility of these facilities which they refer to as "global freight villages". Their study laid out both the characteristics of successful facilities (for example, a minimum of 125 contiguous acres, in or near metropolitan area) and the services which they should provide. Their study, which was primarily aimed at investigating the potential for developing freight villages in Northern New Jersey, described forty freight villages in Europe and examined four in detail. An earlier, and quite extensive study examining the key factors influencing the location of freight facilities found the most important of these is proximity to arterial roads, freeways and services (Young, Ritchie and Ogden, 1980). The facilities examined in this study would have that characteristic.

Missing in previous research is an examination of the question of what types of trucking companies would be interested in using these facilities. Therefore, as part of a larger survey related to trucking company technology use, we queried trucking company managers about their interest in such facilities. Also missing in previous research is industry input concerning the design of such facilities; that issue is outside the scope of our simple investigation. That issue has been addressed in Europe with respect to the design of *intermodal* facilities, referred to as nodal centers (Tsamboulas and Dimitropoulos, 1999). However, those centers are much broader in scope that the unimodal trucking industry centers envisioned here. A current study underway in Dublin, Ireland (Finnegan, Finlay and O'Mahoney, 2004) involves a feasibility analysis of shared use consolidation terminals in that city. The initial feasibility study was focused around a survey of delivery vehicles arriving at a large university campus in the heart of the city.

Data

The Survey

Logistics managers of more than 700 trucking companies operating in California were surveyed in spring 2001. The three-part sample was comprised of: (1) large national carriers with operations in the state of California, (2) California based carriers of all sizes, and (3) private fleets corporately located in the state. The contact lists were obtained from a company that maintains extensive contact information for U.S. trucking companies. Managers of 3438 companies were contacted, and 86% of these qualified by having operations in California.

The response rate was high for this type of survey. As reported in Golob and Regan (2003), of the 2972 companies with California operations, 75% (2218) initially agreed to participate in the survey. For these companies, 712 interviews were completed with the person in charge of California operations. The large number of unresolved contacts reflects the difficulty of tracking down persons responsible and need to schedule call-backs when people have available time. The 712 completed interviews represent a 49% response rate of all resolved contacts, and a 24% response rate of all qualified companies. The computer aided telephone interviews lasted an average of 17 minutes.

Stated Demand for Shared Use Urban Freight Facilities

The question asked was:

> Several public agencies are considering financing the development of shared use urban freight facilities. These would be similar to truck stops, but would be located near urban centers and would provide additional services such as terminal space for consolidation and deconsolidation of loads, as well as internet access. Do you think your company would have any use for such a facility?

Only 18.7% replied that they would have use for such a facility, but another 8.3% chose the "maybe" response; 71.9% replied "no" and 1.1% did not know, as show in Figure 1. Combined, the groups that thought that they would or might use these facilities represented 27% of our contacts – not an insignificant number, especially when one considers that in the US, these facilities do not yet exist. In addition, a large fraction of the trucking industry consists of private fleets, which would have less use for such facilities or local pickup and delivery services which run fairly regular operations. So, this 27% represents a fairly large fraction of all companies that might benefit from such facilities.

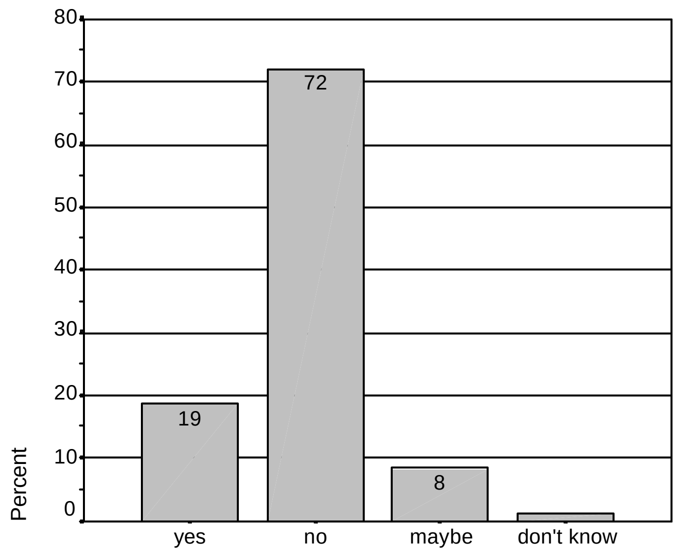

Figure 1. Stated Demand for Shared-Use Urban Freight Facilities

Demand as a Function of Operating Characteristics

Operating Characteristics

In an effort to understand which companies would be more likely to use such facilities, we examined the degree to which demand is related to different ways of characterizing trucking operations. The demand variable was treated as a three-category ordinal scale, after discarding the approximately one percent "don't know" responses. After further eliminating observations with missing data on the exogenous variables, the sample size for the analysis was 683 (96% of the original 712 companies). Since all characteristics are measured in terms of dummy variables, an appropriate measure of the strength of the relationship between stated demand and any individual characteristic is a rank order correlation coefficient. In Table 1 we use the Spearman ρ rank order coefficient, but either of the two Kendall τ coefficients will give similar results.

Examining each operational dimension separately, in terms of overall carrier type, for-hire carriers are more likely to use these facilities than private fleets. The base category is contract carriers, which bridge the gap between for-hire (common) carriers and private fleets. In terms of services provided, demand is higher for any carrier that provides general truckload, van, refrigerated, HAZMAT and high value goods services; demand is lower for carriers providing tanker services.

Table 1 Rank Order Correlations Between Demand for Shared Urban Freight facilities and Individual Operating Characteristics (with non significant (NS) correlations suppressed)

Characteristic	% of sample	Spearman rank-order correlation[a]	Significance
Carrier Type (private, for-hire, or contract)			
Operates primarily as a private fleet	32.0	-0.189	0.000
Operates primarily as a for-hire carrier	51.7	0.183	0.000
Services Provided			
General truckload	66.1	0.110	0.004
General less-than-truckload (LTL)	28.4	(NS)	
Parcel/package delivery	3.5	(NS)	
Household goods movement	7.1	(NS)	
Tanker	8.0	-0.085	0.026
Fat bed/container	19.0	(NS)	
Van	16.7	0.132	0.001
Refrigerated	10.1	0.102	0.008
Construction	9.1	(NS)	
Bulk	7.0	(NS)	
Hazardous materials	9.4	0.117	0.002
High value goods	6.4	0.101	0.008
Size of fleet generally operated in California			
(no fleet size categories with significant correlations)			
Length of haul			
Average loaded movements less than 25 miles	9.3	-0.116	0.002
Average loaded movements 25-49 miles	8.6	-0.099	0.009
(All intermediate categories)		(NS)	
Average loaded movements 500 miles or more	23.2	0.129	0.001
Intermodal			
Maritime intermodal service	35.8	(NS)	
Rail intermodal service	24.0	0.150	0.000
Air intermodal service	30.9	0.110	0.004
Areas of operation in California			
Statewide	49.3	0.151	0.000
Los Angeles Metropolitan Area only	10.7	-0.073	0.050
Northern California, excluding S.F. Bay Area	10.7	-0.090	0.017

[a] positive correlation indicates positive relationship between possessing characteristic and demand for facilities

Demand is unrelated to the size of a trucking company's fleet, as none of the size categories showed a significant relationship with the stated responses. In contrast, length of loaded movement is closely related to demand. Demand is highest for long-haul carriers (defined in terms of average length of loaded movements in excess of 500 miles, 23% of the sample), and lowest for carriers with hauls less than 50 miles (18% of the sample). Carriers with hauls in the intermediate 50 to 500 mile range have neither a positive nor a negative response pattern, indicating that demand for shared-use facilities will be mixed among these carriers (59% of the sample).

In terms of provision of intermodal services, demand is highest for carriers serving rail terminals, and also high for carriers serving airports. There is no apparent relationship between demand and provision of maritime intermodal services. Finally, regarding areas of operations, demand is highest for carriers that operate statewide in California. Lower demand is stated by operators confined to either the Los Angeles Metropolitan Area, or to Northern California, excluding the San Francisco Bay Metropolitan Area. No other areas of operations were found to exhibit significant relationships with demand.

The results listed in Table 1 are useful in identifying which groups of companies are more likely to support urban shared-use facilities. The next step was to estimate a model of demand to determine which of these separate ways of categorizing trucking operations are keys in identifying potential user and non-user groups.

Demand Model Methodology

Defined in terms of a discrete trinomial variable y, the three categories of demand (again excluding the small percentage of "don't know" responses) can be ordered from "no use" (defined as $y = 0$), to "maybe" ($y = 1$), to "yes, useful" ($y = 2$). We postulate that this discrete ordered variable y is a crude representation of a continuous, but unobserved, variable y^* that represents trucking company managers' opinions. If we observed y^* we could apply conventional regression methods that express y^* as a linear function of a vector of independent variables representing trucking company characteristics, denoted by **x**, plus an additive disturbance (unexplained) term ε. The ordered probit model, represents a way to capture effects of **x** on y by using y^*. The model is defined as:

$$
\begin{aligned}
&\Pr(y=0) = \Pr(y^* < \alpha_1) = \Pr(\mathbf{x}\beta + \varepsilon < \alpha_1) = \Pr(\varepsilon < \alpha_1 - \mathbf{x}\beta) \\
&\Pr(y=1) = \Pr(\alpha_1 < y^* < \alpha_2) = \Pr(\alpha_1 < \mathbf{x}\beta + \varepsilon < \alpha_2) = \Pr(\alpha_1 - \mathrm{x}\beta < \varepsilon < \alpha_2 - \mathbf{x}\beta) \\
&\Pr(y=2) = \Pr(y^* \geq \alpha_2) = \Pr(\mathbf{x}\beta + \varepsilon \geq \alpha_2) = \Pr(\varepsilon \geq \alpha_2 - \mathbf{x}\beta)
\end{aligned} \tag{1}
$$

The parameters to be estimated in (1) are α_1 and α_2, the unknown thresholds or "cut points" of y^*, as well as the vector of regression coefficients β. The scale of y^* cannot be determined, so there is no loss of generality in assuming that the variance of ε is equal to one. Assuming also that the disturbance term ε is normally distributed, equations (1) reduce to the ordered probit model originally developed by Aitchison and Silvey (1957) and Ashford (1959):

$$\Pr(y = 0) = \mathrm{F}(\alpha_1 - \mathbf{x}\mathrm{b})$$
$$\Pr(y = 1) = \mathrm{F}(\alpha_2 - \mathbf{x}\mathrm{b}) - \mathrm{F}(\alpha_1 - \mathbf{x}\mathrm{b})$$
$$\Pr(y = 2) = 1 - \mathrm{F}(\alpha_2 - \mathbf{x}\mathrm{b}) \qquad (2)$$

where F denotes the cumulative normal distribution function. If the disturbance term is assumed to be logistically distributed, the same treatment leads to the ordered logit model. Thresholds α_1 and α_2 and the vector b parameters are determined using the maximum likelihood method (McKelvey and Zavoina, 1975).

The ordered probit model expressed in system (2) does not contain a constant term. Some ordered probit formulations have constant terms, but such constants are simply transformations of threshold (cut point) values. In general, for an ordered probit model with c categories, there will be a total of c-1 threshold plus constant parameters. In the present model these are all thresholds, but other formulations use c-2 threshold plus one constant value. A popular approach is to set the first threshold equal to zero (e.g., Greene, 2000), so that the constant is simply the negative of α_1 in (2), and the remaining thresholds in the model with a constant are differences of the thresholds in the non-constant model. In any event, the constants only capture the relative aggregate shares of the categories. We are most interested in the regression parameters which describe how the independent variables are related to differences in responses.

Model Fit

The optimal model was found to have fourteen independent variables. The pseudo R^2 value is 0.22. This suggests a good fit for the this type of model. The parameter estimates are listed in Table 2 together with the asymptotic normal ratios of the coefficient estimates to their standard errors (the coefficient z-statistics). The simultaneous examination of company characteristics and demand for facility use yielded some interesting results in that some variables that were not found to be significant on their own (Table 1) are significant when controlling for other effects. Similarly, some characteristics that appear to be significant when examined alone are redundant when acting simultaneously with other characteristics. This speaks to the importance of examining both univariate and multivariate results in such a study.

Trucking Company Characteristics Most Effective in Explaining Demand

Focusing first on carrier type, the survey data distinguished four types of fleets – for-hire (common) carriers, contract carriers, carriers that operated both as contact and for-hire carriers, and private fleets. All combinations of services were tested. Both the for-hire variable and the contract variable were found to exhibit significant positive demand, so carriers providing both for-hire and contract services have the strongest demand of all. The for-hire effect is the stronger of the two effects.

The parameter estimates listed in Table 2 highlight the importance of carriers' intermodal activities on demand for urban shared use freight terminals. For perspective, Figure 2 shows a breakdown of the intermodal services provided by the companies in our analysis sample. The characteristic with the highest positive impact on demand is provision of rail intermodal service. This points out that rail intermodal carriers in California (24% of our sample) face problematic congestion in the Los Angeles Basin and in the San Francisco Bay Area. These carriers often must make pickups and deliveries to rail yards at peak hours due to schedules over which they have no control. It makes sense that they would benefit from a facility close to their pickup and delivery locations.

Table 2 Ordered Probit Model of Stated Demand for Shared Urban Freight Facilities (N = 683)

Explanatory variable	Coefficient	z-statistic
Provides for-hire services	0.125	4.76
Provides contract services	0.061	2.24
Provides tanker services	-0.180	-13.09
Provides refrigerated services	0.074	3.43
Provides hazardous goods movement (HAZMAT) services	0.182	4.19
Provides high value goods services	0.058	1.78
Fleet size less than 5 power units	0.094	3.33
Average loaded movement < 25 miles	-0.068	-5.33
Average loaded movement 25-49 miles	-0.067	-4.93
Average loaded movement $\geq$ 500 miles	0.065	2.06
Provides air intermodal service	0.069	2.55
Provides rail intermodal service	0.226	5.12
Provides both maritime and rail intermodal services	-0.115	-2.69
Operates statewide in California	0.062	2.13

An interaction effect was also found that involves the joint provision of intermodal rail and maritime services. For carriers providing both rail and maritime services (14% of our sample), the total effect (0.111) is the sum of the two individual effects (0.226 for rail minus 0.115 for joint maritime and rail), which is approximately half that of rail alone. This reflects the fact that some drayage carriers that move loads between ports and rail yards have less demand for shared-use facilities than carriers who provide rail, but not maritime services. Air intermodal operations (32% of the sample) also have a positive effect on demand, but this effect (0.069) is less than that for rail services. As there is no significant interaction effect for air intermodal, this positive influence on demand applies to all intermodal air operators, including those that provide joint air and maritime services (9% of the sample). However, for operators providing all three types of intermodal services (7% of the sample), the estimated effect (a relatively high level of 0.180) is given by the sum of the three intermodal coefficients, including the rail-maritime interaction effect.

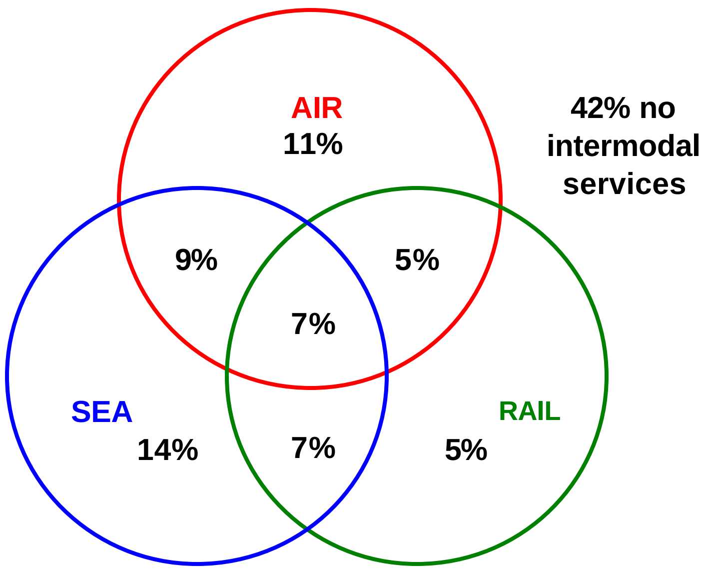

Figure 2. Intermodal Services Provided by Carriers in the Analysis Sample (N = 683)

Results also indicate a relatively low level of demand from tanker operators and a relatively high level demand from operators providing HAZMAT, refrigerated, and high value services, *ceteris paribus*. Tanker operators tend to have mostly fixed routes in which they periodically serve the same relatively small number of customers. As such they would have little need for shared use facilities. As in the case of rail and air intermodal operations, operators providing HAZMAT services are particularly vulnerable to operating in heavily congested areas. HAZMAT drivers are likely have significant amounts of paperwork, which they might be able to get done productively while parked at a shared-use terminal facility. Time is also likely to be valued more highly by carriers with refrigerated and high value

Positive demand by very small fleets, an operating characteristic not found to be significant on its own in the univariate correlation analyses, also emerged in the multivariate model. Operators with less than five vehicles make up a large portion of the trucking industry, and they usually don't maintain their own terminal facilities; if the costs were reasonable, they would be likely users of shared-use terminals.

As in the univariate analyses (Table 1), the model predicts that companies with statewide operations and those with long average movements are more likely to user shared-use facilities, while tanker operators and short-haul carriers are less likely to use them. The estimates show nearly identical negative levels of demand for carriers with loaded movements less than 25 miles and those with loaded movements between 25 and 49 miles. There is no significant effect for the next category of movements (between 50 and 74 miles) and for any other category of movements up to 500 miles, indicating that the relevant cut-offs for the average length of loaded movements are 50 miles on the negative side and 500 miles on the positive side.

Finally, the relationships found in the bivariate analyses between regional operations and demand are not manifested in the multivariate model. Regional effects are picked up by the other operating characteristics in the model.

Demand as a Function of IT Adoption and 3PL Use

We examined the extent to which demand for shared use facilities is related to use of information technologies (IT), since shared use facilities would presumably be equipped with advanced communications technologies. We found that three measures of IT adoption -- use of EDI (electronic data interchange), use of automatic vehicle location (AVL) systems and use of electronic clearance transponders -- were all positively correlated with demand, as shown in Table 3. There are several possible explanations for this significant relationship between all three indicators of IT adoption and demand for shared use facilities. First, the type of operations that benefit from IT improvements might also benefit from shared use facilities. Second, early adopters of technologies may also be companies whose managers "think outside the box" and are more open to new operating paradigms. Or, these managers may see ways that their fleets can take advantage of IT-equipped shared use facilities. For whatever reason, it is clear that the IT components of the design of a shared use facility will be vitally important to the success of that facility.

Finally we also examined the correlation between trucking companies' use of third party logistics (3PL) services and demand for shared use facilities. We suspected that companies that are already cooperating closely with partner companies are less worried about proprietary information than others. In addition, those trucking companies who are already working with 3PLs (34.2% of our sample) tend to be companies without access to their own facilities. The Spearman rank order correlation coefficient between use of 3PL services and demand for shared use facilities was 0.249, corresponding to p=.000. Compared to similar measures of association in Tables 1 and 3, this is greater in absolute value than all of the other correlation coefficients linking trucking company characteristics and demand for shared use facilities. The use of 3PL services is indeed a strong precursor to demand for shared use facilities.

Table 3 Rank Order Correlations Between Demand for Shared Urban Freight Facilities and Selected Information Technology Variables

Characteristic	% of sample	Spearman rank-order correlation	Significance
Company uses traditional electronic data interchange (EDI)	31.9	0.220	0.000
Percentage of vehicles equipped with automatic vehicle locators (AVL)	-- [a]	0.122	0.001
Percentage of vehicles equipped with electronic clearance transponders	-- [b]	0.093	0.014

[a] 66% none, 4% less than 25% equipped; 2% 25-50% equipped; 2% 50-74% equipped; 5% 75-99% equipped; 21% 100% equipped.

[b] 67% none, 94% less than 25% equipped; 2% 25-50% equipped; 3% 50-74% equipped; 3% 75-99% equipped; 16% 100% equipped.

Conclusions

The impact of trucking operations on congestion and reductions in safety and air quality continue to increase. While shared-use urban freight facilities have been considered for many years, their viability as one of many city logistics solutions has not been properly investigated. The cost of facilities located near the urban core does not support the development of profitable truck stops. Therefore, it is likely that these facilities will need to be developed through some sort of public-private partnership. Our objective was to determine the nature of demand for such facilities. The results show that a relatively large group of trucking companies would be likely to use such facilities – in particular, long distance carriers and those providing service to rail terminals are the most likely to use such facilities. Also, IT adoption and use of third party logistics services are indicators of likely users of shared use facilities.

The next question to ask of course would be whether such companies would be willing to pay for access to these facilities and how such charges should be levied. In severe air quality non-attainment areas, there might be sufficient governmental interest in such facilities to warrant public investment. Prior to such an investment, additional survey based research to better estimate demand for various configurations and locations and simulation-based research that could estimate the benefits of making such facilities available to truckers should be conducted. Our study should be considered a preliminary and inexpensive way to begin to examine the question: If we build it, will they use it?

Acknowledgments

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