Issue Paper

Framework for a Disaggregate Truck Trip Generation Model Based on a Survey of Retail Businesses

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ABSTRACT

While considerable strides have been made in forecasting truck travel demand in the past several years, there remain several critical gaps that need to be addressed. The new trends in goods movements like the growth of e-commerce and distribution systems will likely affect the patterns of truck trip generation. Through an extensive literature review, it was found that past truck trip generation analyses used only aggregate variables or proxies of economic activities such as land use types, number of employees, and the gross floor space. Such analyses only indicate the relative importance of trip generators at a general level and ignore the influence of business management and operations decisions such as sales, types of goods, various physical constraints of stores, and socioeconomic characteristics surrounding communities. Preliminary interviews with the experts from a manufacturing plant, a trucking company, and two logistics and supply chain solution providers were conducted. Based on the interviews and literature review, a conceptual framework of truck trip generation analysis has been developed. This paper argues that the truck trip generation should be estimated at the individual facility level because the number and type of freight truck trips are the outcome of a series of decisions about products, sales, locations, delivery times, and frequencies, where the strategic and tactical decisions are made in order to maximize the facility's efficiency and profit by minimizing costs. As an issue paper, this paper reports the experience from an ongoing effort of modeling truck trip generation. First, the paper describes the current trends of truck dominance in freight shipments and its relevance to the current research. Second, a brief discussion of the definition of truck trip generation is followed by the summary of the literature regarding TTG models used in past studies. Then the paper provides the new framework of truck trip generation analysis that is based on the findings from the literature review, studies on business behavior and preliminary interviews. Before concluding, the most difficult task for this study, data requirement and collection strategies are discussed. The paper ends with the discussions on expected outcomes, implications, and contributions of the study.

INTRODUCTION:

Information on the movements of trucks is vital for an effective management of transportation infrastructure. While goods movements by trucks play a critical role in the national and regional economy, trucks are also responsible for most of the pavement damage, a sizable portion of air pollution from non-stationary sources, and congestion (Transportation Research Board, 2002). According to the Federal Highway Administration (February 25, 2003), the domestic truck VMT in the U.S. is projected to increase by more than 70% between 2000 and 2020.

While considerable strides have been made in forecasting truck trip generation in today's complex supply chain environment, there remain several critical gaps that need to be addressed. It is certain that the growth of E-commerce, logistics and supply chain management concepts as well as a group of goods distribution strategies known as "City Logistics" (Taniguchi et al., 2001) are affecting the pattern of freight flow in urban areas. In other words, the changes in logistics and supply chain have shifted the freight transportation demand from production-schedule-related push logistics to demand-responsive pull logistics. Therefore, it is evident that currently available demand forecasting methods are not suited to address those changes.

As the first step toward the development of a truck demand forecasting model that can account for the logistics and supply chain management strategies used by today's businesses, this study will tackle the most fundamental but often neglected component of the truck travel demand forecasting process, trip generation.

As an issue paper, this paper reports the experience from an ongoing effort of the development of a new generation of truck trip generation models. First, the paper describes the current trends of truck dominance in freight shipments and its relevance to the current study. Second, after briefly providing the definition of truck trip generation (TTG), the discussion is followed by the summary of the literature regarding TTG models used in past studies. Then the paper provides the new framework for the TTG analysis that is based on the findings from the literature review, studies on business behavior, and preliminary interviews. Before the concluding remarks, the strategy for data collection is fully addressed, since it is the most critical and yet most difficult part of the research. The paper ends with the discussion of expected outcomes, implications, and contributions of the study.

RECENT TRENDS:

There have been several driving forces that have led many transportation professions to pay more attention to the growing goods movements by trucks and their impacts on the economy, roadway infrastructure, and the environment. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 required that Metropolitan Planning Organizations (MPOs) include freight transportation components in MPOs' Regional Transportation Plans (RTPs), Transportation Improvements Plans (TIPs), and annual work elements (USDOT, 1991). The Transportation Equity Act for the 21st Century (TEA-21) of 1998 followed its predecessor. Both pieces of legislation emphasized seamless goods movement (intermodality) and the efficient management of the National Highway System that serves as the important element of automobile and freight truck flows and the U.S. economy.

Recent data indicate that trucks are becoming increasingly dominant in goods movements in urban areas. For example, the proportion of urban interstates that carry more than an average of 10,000 trucks per day is expected to increase to 69% in 2020 from 27% in 1998 (FHWA, February 12, 2004). Surprisingly, a recent estimate predicts the volume (tons) of freight transported by trucks will grow by over 75% in the next 15 years (FHWA, 2002). In the Chicago region, 75.3% or 220 million tons of commodities originating in the region ended within 50 miles of their origin; among those shipments, trucks shipped 90.3%, or 199 million tons (U.S. Bureau of Census, 1997). Such dependence on trucks has influenced congestion and improvement needs on roadways and freight-related facilities.

In addition, the widespread adoption of logistics and supply chain management (SCM) strategies has changed the pattern of goods movements from push logistics to pull logistics. That is, the paradigm of goods movements has shifted from manufacturer- or supplier-led shipments (push logistics) to consumer-led shipments (pull logistics). Such changes to the flexible production and lean inventory management systems have been propelled by the development of just-in-time (JIT) and e-economy (or e-commerce). During the mass production era, most shipments were based on point-to-point bulk shipments, while the era of flexible production and lean inventory systems are characterized by more frequent goods movements with smaller and lighter shipments (Suarez-Villa, 2003). These trends may affect trip rates, volume, and goods distribution.

In summary, three trends were discussed. First, the federal government has recognized the importance of seamless freight movements to the economy. Second, several estimates indicate the growing trend of goods movements by trucks. Finally, changes in the goods movement behavior derive more frequent freight deliveries by trucks.

OBJECTIVES OF THE STUDY

TTG is a study to estimate the number of trucks coming in and out of a study area. The analysis will help transportation planners and public agencies to provide information to aid policy and planning decisions. Despite this promise, we argue that TTG analysis has not achieved its goal of providing reliable information to the decision makers due to the lack of data and appropriate methodology as described below.

The lack of data affects every facet of the modeling of truck behavior. Accurate demand forecasting and the quantification of the impacts of truck activities can be accomplished by using better data (Holguin-Veras & Lopez-Genao, 2002). Unfortunately, data collection efforts in the public sector have been limited, since freight-related data are considered to be the private property and the publicly available data are only released at the state or urban area levels (Pendyala, Shankar, & McCullough, 2000). Although more detailed data are available from private data bases like Reebie Associates' TRANSEARCH, the price of the data limits the extensive use of the data in many regions.

Because of these reasons, the existing models for truck trip generation (or truck travel demand) are mostly based on the data that are relatively easily available at the aggregate level. Past TTG analyses were mostly based on zonal level data. In other words, variables or proxies of economic activities such as land use types, number of employees, and the gross floor space that were spatially aggregated were used for TTG estimations. Consequently, existing models only indicate the relative importance of trip generators at a general level and are not suited to analyze the impacts of the changing goods movement patterns from push logistics to pull logistics noted earlier. In addition, the results diverge; indicating such aggregate approaches cannot capture the relationships between economic activities at individual facilities and the number of freight truck trips.

The proposed study presents a different perspective on the relationships between TTG and economic activities. Freight transportation demand is directly related to "managerial, operational or tactical decision of production, consumption or sales decisions" (Wilson, 1980) of an individual business that is consumer-demand responsive. The business put most efforts on increasing profit by keeping supply chain management costs as low as possible. Transportation is subject to such cost reduction efforts. Therefore, it is assumed that the number of truck trips coming in and out of a business is reflected in the business' operation. We argue that if detailed variable at the individual business level is collected, it will be possible to find out the variable that will accurately estimate the number of truck trip demand. The goal of the paper is to review the issues of past and current truck travel forecasting models, suggest a new framework for truck trip generation, discuss our data collection efforts, and provide a strategy to pursue future research. The specific objectives are to

(1) Address the problems with the past and existing TTG models,
(2) Provide the findings from interviews with experts in the private sector,
(3) Suggest a new framework for measuring TTG that will be used for our future study,
(4) Present the difficulties faced and the strategies used for our data collection effort, and
(5) Discuss our future strategy for further research.

LITERATURE REVIEW

Commodity-based vs. Trip-based Approaches

The commodity-based approach to TTG estimation focuses on the quantity and the types of goods movements by various types of vehicles, while the trip-based approach deals with traffic flows in terms of the types of vehicles and their operations (Garrido, 2001). That is, the commodity-based approach first focuses on estimating tonnage of commodity flow and covert such flow to the number truck trips. By contrast, the trip-based approach directly measure the number of truck trips. However, the more practical distinction between the two approaches is characterized by data availability and the objective of the model. The trip-based approach is usually applied site-by-site, while the commodity-based approach is applied at the zonal or regional level. Since the zonal-level economic data are more available than the site-level information, the commodity-based approach is the one that is more frequently used if the goal of a study is to forecast area-wide truck trips.

Although the commodity-based approach has been extensively studied, it can result in underestimating the number of truck trips since trip chaining and local pickup and delivery cannot be accounted for by this approach (Fisher & Han, 2001). On the other hand, the trip-based approach directly measures the number of truck trips.

However, the limited data availability on truck flows has kept researchers from obtaining generalized (transferable) results.

Techniques of Truck Trip Generation Analysis

Trip Rate Method

One of the earliest attempts to model TTG was carried out using the trip rate method that measured the number of truck trips by gross floor space, employees and land use classifications. Brogan (1979) found that the trip rate method is a good measure for a short-term plan for a small study area. This method is probably simplest and straightforward. However, the results based on trips per a single independent variable "vary highly from one region to another and within region (Fisher & Han, 2001)."

Comment [J1]: That is, it allows for short-term forecasting of traffic flows?

Comment [J2]: You cite three independent variables. Why do you say the model uses only one independent variable?

Regression Analysis

The most widely used technique for the estimation of TTG is regression analysis. Regression analysis measures the number of truck trips as a function of one or more independent variables, such as land use, population, employment, and other socio-economic variables (Slavin, 1974; Brogan, 1979 & 1980; Tadi & Balbach, 1994). Recent applications of regression analysis were focused at the site-specific level, such as marine container terminals (Al-Deek et al, 2000; Holguin-Veras and Lopez-Genao, 2002). For example, Al-Deek at al. (2000) estimated the number truck trips as a function of imported and exported containers at the Port of Miami, Florida.

Statistically speaking, the process of regression analysis is straightforward and well understood. However, the models used in past studies utilized observable data that only show the proxies of freight activities at a study region or a site. Except a site specific study at ports (Al-Deek et al, 2000; Holguin-Veras and Lopez-Genao, 2002), most studies used variables that were spatially aggregated so that changes at the individual business levels could not be captured. In case of the site level analysis, the resulting methodology can be transferred to a similar site. Klodzinski & Al-Deek (2003) successfully applied a model created for the Port of Miami, Florida to other ports in Florida. Their results imply that a disaggregate TTG model may yield a more generalized and transferable model structure than spatially aggregated models.

Trip Matrix Estimation

Although trip matrix estimation has been an area of research for some time, the application to freight travel demand model is relatively new. For example, List and Turnquist (1994) developed a method for estimating multi-class OD truck trip matrices from three different data sources: (1) link volumes or classification counts, (2) partial OD estimates, and (3) cordon counts. OD Trip matrices were estimated for three truck classes: van, medium and heavy trucks. They concluded that the truck flow changes were related to the commodities being carried and the physical characteristics of trucks.

If detailed data for trip matrices are available, it is possible to estimate a relatively accurate trip generation for each point or zone of concern. However, the availability of data, as usual in freight planning, poses a significant challenge to researchers, requiring various estimation techniques on the basis of a combination of different data sources. In addition, as the aggregation level of the data decreases, the size of an O-D matrix and also the computational burden exponentially increase.

Artificial Neural Network

Recently, several TTG studies used an artificial neural network (ANN) model. The ANN model was applied to three ports in Florida: the Port of Jacksonville, the Port of Tampa and Port Canaveral (Al-Deek, 2001; Klodzinski & Al-Deek, 2003). While we cannot explain the structure of ANN models adequately in the space available, ANN is a machine learning technique that tries to imitate the function of human nerve system consisting of neurons and neuron synapses. In the model, the relationships between the number of truck trips and the independent variables are modeled as a network consisting of several layers – a layer of independent variables, a hidden layer, and a destination layer.

As for the selection of appropriate independent variables, which is one of the important issues in TTG, the ANN model could automatically select them. In addition, it could detect complex relationships between dependent variables and independent variables. However, the major disadvantages of an ANN are the lack of well-defined guiding rules for developing a network, its dependence on a researcher's intuition in deciding the model's stopping criteria of simulation, the computational burden, and the requirements of the detailed data (Al-Deek, 2001; Klodzinski & Al-Deek, 2003).

Behavioral Approach

Over the years, the focus of the research on truck trip generation has been expanded from the analysis of easily observable data to the incorporation of the behavioral components of business activities. This trend reflects the fact that the relationships between economic activities and transportation flows are not static; rather, they are affected by various strategies of different industries (Iding et al., 2002). In other words, decision characteristics of businesses are latent variables that influence the truck trip generation. Such characteristics are reflected well in a supply chain of a business. In this sense, a review of supply chain management (SCM) strategies will help us to estimate the number of truck trips by incorporating the variables observed from the supply chain management strategy adopted by the businesses.

Although the detailed components vary by firms and studies, Mentzer (2001) likened the supply chain to the "pipeline" through which information regarding products, services, financial resources, demand, and forecasts flows. Such flows play a role in coordinating inter-firm decisions such as marketing, sales, research and development, forecasting, production, purchasing, logistics, information systems, finance, and customer service. Transportation management in a supply chain involves the choice of shipping schedules, methods, and time tables, the purpose of which is to minimize shipping costs (Gaither & Frazier, 1999)

Several types of research on SCM can be found. Boerkamps et al. (2000) developed a conceptual model, "GoodTrip model," to estimate freight movements. The model reflects the interactions among markets, actors, and supply chain elements of urban freight movement. The model begins by recognizing the lack of behavioral aspects in the traditional freight demand models. That is, the authors try to incorporate the behavioral interaction between consumers' demand on various goods and the response of shippers, producers, carriers, and other freight related interests in a supply chain: "starting with consumer demand, the model estimates goods flows and simulates vehicle tours (Boerkamps et al. 2000)." Considering these interactions in market would yield a more practical estimation of a goods distribution system. Simply, the model is the application of the traditional four-step travel forecasting model to supply chain, which is a mid-scale model between zonal-base four step model and disaggregated logistics models. Although the model has not been mathematically constructed yet, it provides an insight into the future development of a freight demand model. That is, changes in the supply chain will explain the behavior of freight flows.

Another interesting study is the application of the network equilibrium model to a supply chain. Nagurney et al. (2002) created a hypothetical network model of a supply chain consisting of two manufacturers, two retailers and two consumers. It was assumed that there is a flow of only one homogeneous product. The objective function was created to reflect the cost minimization behavior of manufacturers and retailers, and consumers' desires to maximize consumptions under the given budget limits and market conditions. This model oversimplified the real world network yet provided good insight with regard to the truck travel demand model. This is because the use of the production function to estimate the flow of shipment between firms and retailers provides valuable information regarding the relationships between freight travel and the variables in the production function.

In the SCM studies mentioned above, transportation was treated as a cost component to be minimized in order to facilitate the efficient flows of goods and services. Unfortunately, literature review conducted so far could not find a research that addresses the independent variables influencing truck trip generation.

A brief summary of the findings and the implications for this study are as follows:

(1) Since the commodity-based approach does not directly estimate the number of truck trips, the trip-based approach is more appropriate for this study.

(2) The trip rate method is a simple and easy approach to measure trip generation. However, it is not suited for forecasting purposes since the trip rates based on land area vary significantly from region to region and even within a region.

(3) Regression analysis has been identified as the dominant approach used for the estimation of truck trip generation. Despite its popularity and long tradition, no consensus has been reached on the choice of independent variables. However, recent research at the site-specific level suggests that the analysis for a specific site can produce consistent results and can be transferred to other sites with similar characteristics. This suggests that a disaggregated level of analysis may yield a feasible result with regression.

(4) The application of the ANN could detect the complex relationships between dependent variables and independent variables. However, the long process of trial and error, and the lack of defined rule on network design are problematic. Despite such limitations, ANN model is attractive since no priori assumption regarding the functional form of the relationships between the input variables and the outcome needs to be made.

(5) The estimation of O-D matrices tries to overcome the problem of the lack of data. However, as is common in freight transportation planning, the availability of the data poses a significant challenge to researchers. Even when detailed data are available, a

disaggregate analysis at the individual business level may exponentially increase the size of a matrix and consequently the costs, time, and complexity of the analysis.

(6) In SCM, transportation is treated as a cost component to be minimized for facilitating efficient goods movement. The application of the behavioral aspects of the businesses in a supply chain is expected to provide an alternative for estimating truck trips. Although a substantial amount of detailed data are required, a more accurate analysis and prediction are probably possible. Despite the difficulty associated with the collection of necessary data and constructing a model, the promise of this approach lies in the fact that understanding business behavior – e.g. shipment decision depending on seasonal variability - will lead researchers to discover more consistent independent variables for explaining the demand of truck trips. Since the approach adopts the decision variables of industries, it can be expected that grouping industries with similar characteristics may have similar decision variables that are not reflected in the past TTG analysis.

FRAMING A TRUCK TRIP GENERATION MODEL

Framing the issues

In the previous section, the lack of data and adequate methodology are identified as the most problematic issues in TTG modeling. The data and methodology problems are also related to the level of analysis. It is a truism in microeconomics that the sum of the individual demand curves is a market demand curve. That is also the case in transportation demand analysis. The existing models are prone to large aggregation errors since the models cannot capture the heterogeneous characteristics of the individual businesses in a study area.

This study frames TTG with a different perspective on the relationships between truck trips and economic activities. At the individual firm level, the number and type of freight truck trips within a given time period can be regarded as an outcome of a series of decisions about products, sales, locations, delivery times, and frequencies (Iding et al., 2002). That is, TTG is directly related to decision-making behavior with respect to supply chain management (SCM) and logistics strategies adopted, as the firm's goal is to maximize profit.

Comment [J3]: Are these the "behaviors" that your "behavioral" model focuses on? Can you give some specific examples?

Comment [J4]: As noted above, maximizing profit is generally not consistent, except in an approximate way, with behavioral models.

Analysis at the large geographical level implicitly ignores heterogeneity in the characteristics of businesses in a study area. However, different SCM strategies can be employed by different businesses. For example, Figures 1 and 2 are conceptually created based on literature reviews and discussions with other transportation professionals. The Figures display two different supply chain networks. Both figures describe the relationships between a retail store and its suppliers or distribution centers (DCs). In Figure 1, there are four types of inbound truck shipments associated with a retail store; two shipments are made from suppliers' DCs, one from a retailer-owned DC and a direct shipment from a supplier. On the other hand, a retail store in Figure 2 receives a shipment only from its own DC where all shipments either by less-than-truck-load (LTL) or by truck-load (TL) are consolidated and distributed. The latter example has become common in the supply chain management field, since the number of trips – transportation costs - to a retail store can be minimized. This is the relationship and trends that cannot be captured in existing TTG analysis models.

Figure 1: Supply Chain System and Truck Trip to a Retail Store - Configuration 1

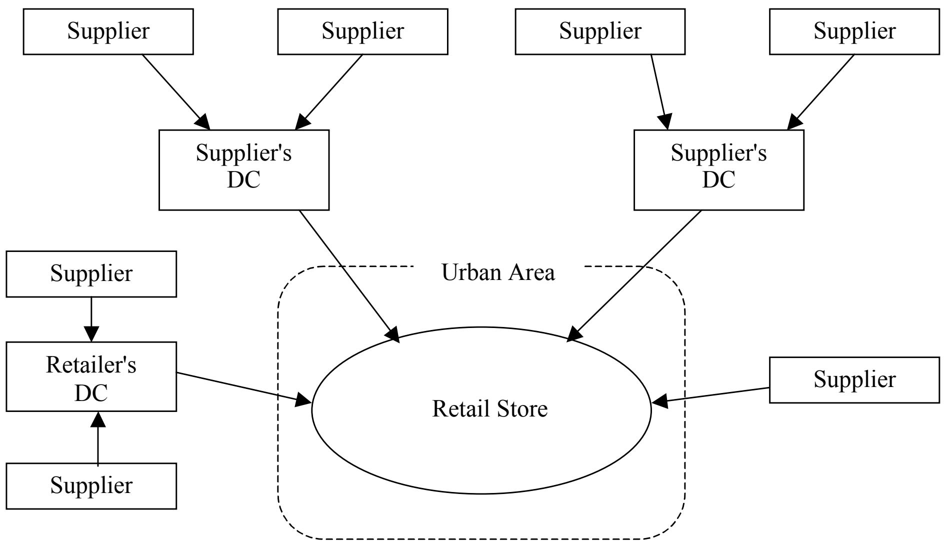
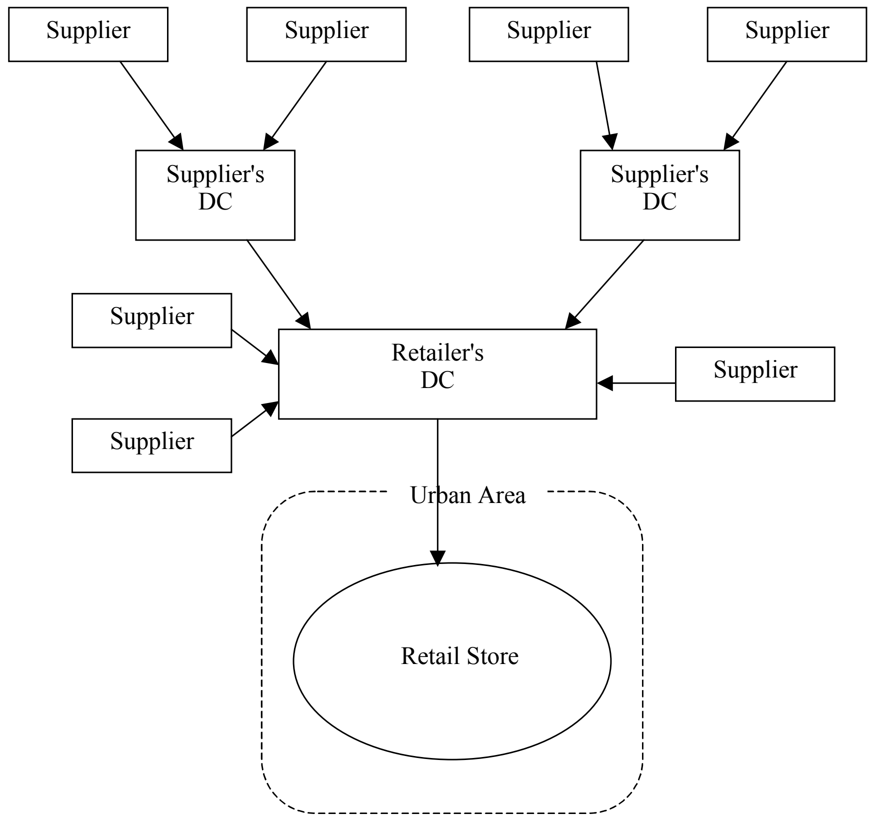


Figure 2: Supply Chain System and Truck Trip to a Retail Store - Configuration 2



A Framework for TTG Analysis

Preliminary interviews with experts from a manufacturing plant, a trucking company, and two logistics and supply chain solution providers were conducted. The purpose of the interviews was to obtain feedback on TTG models, develop a conceptual framework of business' decision-making process and the input factors related to truck trip generation, and identify possible data sources and industry sectors of interest.

The interviews generated several conclusions. First, all interviewees agreed that a disaggregate TTG analysis at the site-specific level would capture the activities of individual facilities. Second, distribution centers (DCs) and big box retail stores were recommended by the interviewees as the facilities at which consistent behaviors in business operation in terms of TTG would be observed or estimated. Especially, DCs can be a rich data source not only for their own trip generation, but also for the activities of individual big box retail stores. Also, the retail sector provides daily necessities for consumers, bringing the research to the concerns of the public; consumer industries account for a large share of the American economy.

The resulting framework, depicted in Figure 3, is based on several assumptions:

(1) The number of truck trips is directly related to the activities of individual facilities where the strategies and actions may depend on the unique circumstancesin order to maximize a facility's efficiency and profit by minimizing cost.

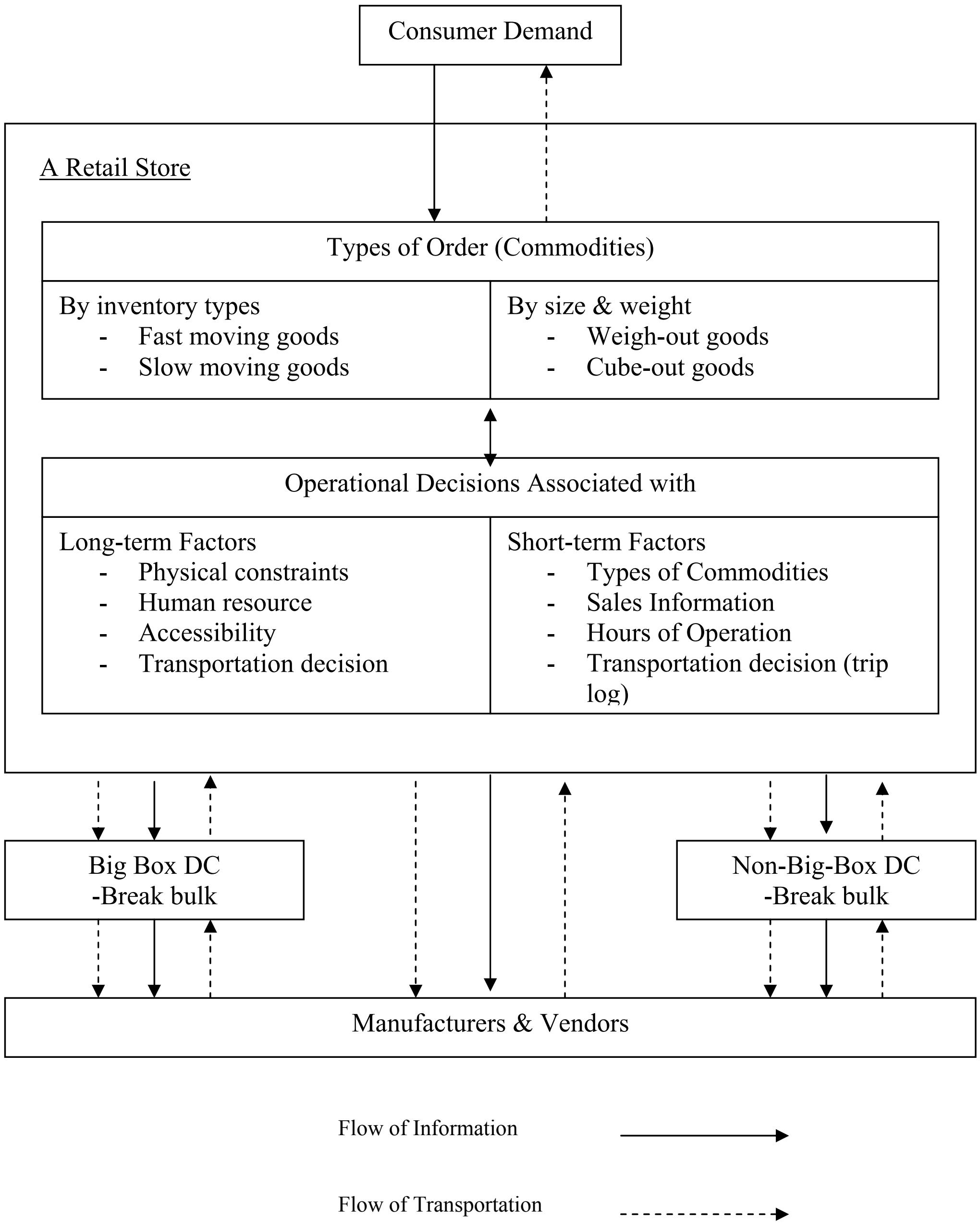
(2) Types of goods traded in the DCs and retail stores are related to the patterns of truck trips such as the frequency, types of trucking modes (e.g. TL, LTL, parcel) , time of day decision, and seasonal variability of truck trips and so on.

First, the small box on the top of the figure implies that the most important factor of freight truck demand is consumer demand for different types of goods. The demand for truck trips will be best estimated at the individual facility level since the number of truck trips is influenced by the way in which the facility operation is responsive to consumer demand. However, the inclusion of numerous commodities in a model is probably not feasible in most cases since the trade-off between the data requirement and the marginal improvement in the accuracy may not be favorable. Instead, it is assumed that there are four types of commodities: fast-moving and slow-moving goods in terms of the velocity of inventory turns and weigh-out and cube-out goods in terms of size and weight concerns on shipments.

Second, the bottom of the middle box shows the variables that need to be considered in a TTG modeling process (Appendix A shows the possible list of data). The variables are classified as long-term factors and short-term factors. The long-term factors include such variables as physical constraints of a facility and human resources. In this model, these variables are tested in order to see if they are useful predictors for a long-term TTG forecast. On the other hand, the short-term factors are associated with daily operations of a business. Such variables as replenishment schedule and sales information are the most important variables. The variation of sales volume over time will show the seasonal variations in business operation that may be related to the number of truck trips. A trip log will show the transportation management strategy of DCs or retail stores including the replenishment schedule.

Comment [J5]: Assuming these variables are available for estimating the model, will they be available for making forecasts with the model? How useful will this model be, assuming you can estimate it?

Third, three boxes on the bottom of the Figure 3 are suppliers of commodities. As noted earlier, there are several different shipments patterns between a retail store and suppliers or DCs. Only three types of inbound shipments to a retail store are assumed.



DATA COLLECTION STRATEGY

In the previous sections, the problems with the aggregate TTG models have been addressed and a new research framework has been proposed. However, the real challenging part of any model development is the gathering of required data. This section discusses the strategies used and difficulties faced in the data collection.

Data Collection Strategy

(1) Building the Knowledge Base
As discussed previously, the research team consulted field experts before the inception of the data collection. The purpose was to get a grasp on the relationship between the generation of truck trips and the business decisions made at various levels. We hypothesized that the past TTG studies mostly focused on long-term variables, and overlooked the importance of short-term business decisions made at the individual facility level. In the past, the freight transportation planners have rarely interacted with the people who make those decisions. Thus, it was an inevitable step for the research team to consult the practitioners to build a knowledge base on their day-to-day activities and to understand how freight issues are dealt with from the perspectives of the logistics or supply chain management. Another purpose was to identify the sectors that may be good sources of data. As mentioned earlier, big box DCs and retail stores have been selected as focal groups of interest.

(2) Creating Contact Information
Considering the amount of resources available to collect data, it was decided that the data would be obtained from the DCs and retail stores in Illinois, Indiana, Ohio, and Wisconsin. Once that decision was made, the next step was to create a sampling frame by generating a contact list for potential data sources. The list of businesses with street level addresses was obtained through the internet search. However, the contact information for potential data sources, i.e., personnel in logistics or supply chain management position within the companies, was difficult to obtain. The strategy used was to use the membership directories of professional organizations in the field of logistics, retail, and supply chain. In some cases, one of us had to become a member to obtain the directory. From the directory, we collected the phone numbers and e-mail addresses. We quickly discovered that this was probably the most efficient approach for building a contact list since, by focusing on the organizations in the logistics and supply chain fields, the membership directly only included the individuals with a background in those areas. To a large extent, this resolved the problem of finding the appropriate contact within the organization.

(3) Data Wish List
In parallel with the creation of the contact information, the research team generated a data wish list. The purpose of the wish list was to document the types of data and also possible sources where the information could be found. The wish list was sent to the contacts, once they agreed to participate, to communicate the exact information we were trying to obtain. Compared against using a survey instrument, this approach provided the contacts more flexibility in terms of the format and means to deliver the data. The drawback was

that it required a follow-up with phone calls or other means to go over the list to ensure that the contacts had a clear understanding of the data being sought and make necessary arrangements to obtain them.

It was found that the language in the wish list had to be carefully developed and refined in order to clearly convey what the research team wanted from the contacts. For example, the most critical material was a "travel diary" between a DC and retail stores. Although travel diaries are a common tool used by transportation planners to collect travel information, logistics professionals express the concept differently, e.g., a route schedule or replenishment schedule. The appendix shows the data wish list sent to the interviewees.

Difficulties Encountered

Once the contact list and the wish list were created, an initial round of contacts was made. While waiting for responses from the contact list, the following problems surfaced and will have to be solved throughout the study.

(1) While the contact list reduced the problem to some extent, it was still problematic to reach the right person to contact. The job title on the membership directory alone did not guarantee that the initial contact was the right person. Often, we were referred to different individuals or departments within the company.
(2) Much of the information included the data wish list is considered confidential by the businesses. Consequently, the decision for providing the data had to be made at a high level even when the data were available, causing a delay.
(3) In many cases, the businesses had to be provided with a certain incentive or motivation to participate in the study. One possible incentive is to provide the study results to participants so that they can benchmark their performances relative to the sample.

EXPECTED CONTRIBUTION OF THE FRAMEWORK

One of the key aspects of the proposed framework is to connect individual business behaviors to freight truck demands. The flow of information (e.g. location decision, production decision, inventory decision, distribution decision, and transportation decision) in a supply chain has a direct impact on the estimation of TTG. In this sense, this framework is expected to have a greater depth of analysis compared to past studies.

(1) The study recognizes the direct impacts of a businesses' decision-making on the demand for truck trips. In theory, consistent relationships between truck trips and business specific decision variables can be identified because each business tries to optimize cost and revenue, and businesses in a similar group have similar patterns of trip generation.

(2) The variables identified in the study can be used for developing a better TTG model in the public sector.

(3) Trip generation should be measured at a disaggregate level and then aggregated to a larger level (Kanafani, 1983). The availability of a proper methodology at the disaggregate level will be a valuable input for developing a regional truck travel model.

(4) The direct estimation of TTG at a disaggregate level based on business-specific variables by firms provides substantial information for policy decision-making regarding infrastructure improvements and site impact analyses.

(5) A long term impacts of new trends, such as City Logistics, E-Commerce and the just-in-time logistics system, are probably understood from the model. For example, in the long run, small package delivery directly to a household from the DC may increase in response to the increase of the use of e-commerce.

(6) Since this study provides an understanding of an individual firm behavior and its relationships to TTG, it provides valuable information that fills the knowledge gap between the public and private sectors.

CONCLUSION: ISSUES FOR THE FURTHER DEVELOPMENT

In this paper, the problems of the existing models of TTG analysis have been reviewed. A new framework of TTG analysis has been proposed on the basis of the findings from an extensive literature review and a set of preliminary interviews with experts in logistics and supply chain management. Despite the expected contributions from the possible outcome, there still remain a couple of issues that need to be addressed for the further development of the TTG Model.

The first and the most important issue with TTG is data availability. In most cases, private businesses consider their store information proprietary. It is a good strategy for a researcher to emphasize to the participants the tangible benefit that will be generated from the outcome of the study. However, it is not easy to provide examples of advantages to attract private businesses.

The second issue is the selection of appropriate methodology. A proper methodology cannot be identified until the completion of the data collection. However, it is a good idea to compare the outcomes from the various methodologies. It will be possible to find a desirable methodology for TTG at the individual levels.

The third issue involves the types of independent variables. For a more comprehensive study of TTG and to find a more consistent variable, a researcher should not limit the number of independent variables. By examining different types of independent variables, it may be possible to find adequate variables for different sectors of industry. In addition, the variables used in past studies, such as land use types, the number of employees, and the gross floor space, should be collected. Such variables can be used to determine whether they are still statistically valid at the disaggregate level of analysis.

The fourth issue is the selection of the businesses to be included in the study. The study should begin with businesses with a relatively simple supply chain between DCs and retail stores, while excluding the businesses with complicated supply chains, because the calibration of the model may not be computationally reasonable. For example, a shoe manufacturer included in the contact list for the study has only one DC in the Midwest region that serves all 237 retail stores in the U.S. Another shoe manufacturer has two DCs in the West and Midwest, respectively, that serve the entire mainland U.S. Such businesses will be good starting points to build a pilot study that will be the basis for a more sophisticated model with more complex supply chains.

REFERENCE:

Al-Deek, H.M., Johnson, G., Mohamed, A. and El-Maghraby, A. 2000. Truck Trip Generation Models for Seaports with Container and Trailer Operation. *Transportation Research Record* 1719: 1-9.

Boerkamps, J.H.K., van Binsbergen, A.J. and Bovy, P.H.L. 2000. Modeling Behavioral Aspects of Urban Freight Movement in Supply Chains. *Transportation Research Record* 1725: 17-25.

Brogan, J.D. 1979. Development of Truck Trip-Generation Rates by Generalized-Land Use Categories. *Transportation Research Record* 716: 38-43.

Brogan, J.D. 1980. Improving Truck Trip-Generation Techniques through Trip-End Stratification. *Transportation Research Record* 771: 1-6.

Cambridge Systematics, Inc. 1996. *Quick Response Freight Manual*. <http://tmip.fhwa.dot.gov/clearinghouse/docs/quick> (2004, March 3).

Federal Highway Administration. 2002, October. Freight Analysis Framework. *Freight News*.

Federal Highway Administration, *FAF State to State Commodity Flow Database*. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/fafstate2state.htm (2003, February 25).

Federal Highway Administration. *The Freight Story*. <www.ops.fhwa.dot.gov/freight/publications/freight%20story/freight.pdf> (2004, February 12).

Fisher, M.J. and Han, M. 2001 *Truck Trip Generation Data (NCHRP Report 298)*. Washington, D.C: TRB, National Research Council.

Gaither, N. and Frazier, G. 1999. *Production and Operations Management. Eighth Edition*. Cincinnati, OH.: South-Western College Publishing.

Garrido, R.A. 2001, August. *Insights on Freight and Commercial Vehicle Data Needs*. Paper presented at International Conference on Transport Survey Quality and Innovation, Kruger National Park, South Africa. <http://www.its.usyd.edu.au/conferences/international_conference_on_transport_survey_quality_and_innovation%20(new)/workshop_papers.htm> (2004, April 14).

Holguín-Veras, J. and López-Genao, Y. 2002. Truck Trip Generation at Container Terminals: Results from a Nationwide Survey. *Transportation Research Record* 1790: 89-96.

Iding, M.H.E., W. J. Meester, and L.A. Tavasszy. 2002. *Freight Trip Generation by Firms*. Paper presented at the 42nd European Congress of the Regional Science Association. Dortmund, Germany.

Kanafani, A. 1983. *Transportation Demand Analysis.* New York: McGraw-Hill Book Company.

Klodzinski, J. and Al-Deek, H.M. 2003. Transferability of an Intermodal Freight Transportation Forecasting Model to Major Florida Seaports. *Transportation Research Record* 1820: 36-45.

List, G.F. and Trunquist, M.A. 1983. Estimating Truck Travel Patterns in Urban Areas. *Transportation Research Record* 1430: 1-9.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G. 2001. Defining Supply Chain Management. *Journal of Business Logistics*, 22 (2): 1-25.

Nagurney, A., Dong, J., and Zhang, D. 2002. A Supply Chain Network Equilibrium Model. *Transportation Research, Part E.* 38: 281-303.

Pendyala, R.M., Shankar, V.N. and McCullough, R.G. 2000. Freight Travel Demand Modeling: Synthesis of Approaches and Development of a Framework. *Transportation Research Record* 1725: 9-16.

Slavin, H.L. 1974. Demand for Urban Goods Vehicle Trips. *Transportation Research Record* 591: 32-37.

Suarez-Villa, L. 2003. The E-economy and the Rise of Technocapitalism: Networks, Firms, and Transportation. *Growth and Change.* 34 (4): 390-414.

Taniguchi, E., R.G. Yamada, T.T. and van Duin, J.H.R. 2001. *City Logistics.* Elselvier.
Transportation Research Board. 2002. *Regulating Weights, Lengths, and Widths of Commercial Motor Vehicles (Special Report 267*). Washington, D.C.: TRB, National Research Council.
U.S.Bureau of Census. 1997. *1997 Commodity Flow Survey* (CD-EC97-CFS). Washington, D.C.; U.S. Department of Commerce.
USDOT. 1991. A Summary - Intermodal Surface Transportation Efficiency Act of 1991, Washington, D.C.
Wilson, G.W. 1980. *Economic Analysis of Intercity Freight Transportation.* Bloomington, IN: Indiana University Press.

APPENDIX: DATA WISH LIST

This list includes the data that the research team would like to obtain. As a first step, we are contacting the distribution centers (DCs) because in many cases, the DCs maintain the detailed shipment information to and from each retail store that we are looking for.

I. Truck Trip Information

I-1 Coverage

Information regarding:

(1) The geographical territory that your DC covers

(2) The number of stores attached to your DC function

I-2 Route schedule

Information regarding:

(1) The factors that determine the route schedules of the shipments to the stores

(2) All the route schedule patterns (time and location of each stop, travel distance between each stop, frequency of route per week) used by your DC to replenish the retail stores in Illinois, Indiana, Ohio, and Wisconsin. The information for a longer time period (e.g. one year) is preferred. Otherwise, the data from typical days, weeks, months or quarter will be desired (the questions regarding the seasonal variation in the route schedule is addressed below). We assume that such information will capture the characteristics of truck trip generation in your place and retail stores that you serve.

(3) All the seasonal/special route schedules (time and location of each stop, travel distance between each stop, frequency of route per week) used by your DC, and the time periods you use such schedules.

(4) The factors that determine the replenishment frequency for each store

I-3 Store replenishment

For each of the stores in Illinois, Indiana, Ohio, and Wisconsin that are covered by your DC, we would like to obtain the following data.

(1) The number of replenishment deliveries from your DC per week

(2) The average cubic feet of shipment per delivery

(3) The average weight of shipment per delivery

(4) The average value of shipment per delivery

(5) The sizes of containers used for shipment

(6) The average dwell time per stop

(7) The percentage of shipments delivered by outside vendors or other DCs of your company by trips, cubic feet, weight, value

(8) Schedule for the deliveries by outside venders

(9) The process of the shipments by outside vendors.

II. Retail Store Information

For your DC and each of the retail stores within Illinois, Indiana, Ohio, and Wisconsin

(1) Address

(2) Gross Floor Space (GFS)

(3) Number of employees by month

(4) Number of docs

(5) Truck parking space size

(6) Drop lot space size

(7) Hours of business and operation

III. Discussion: Logistics and Supply Chain Information

It is assumed that the choice of different strategy will influence truck trip generation

(1) What are the factors that determine departure time of shipment?

(2) What types and size of trucks do you have?

(3) In case of for-hire trucks, is there any decision rule for selecting shipment mode between truck-load (TL) and less-than-truck (LTL)?

(4) Many discussions on the new technology and strategies have been made in the areas of supply chain management, logistics, distribution and inventory management. What is the strategy for the efficiency of you distribution network? Do you use any types of DC management tools or technology?

(5) In a supply chain network, the transportation is obviously one of cost components to be minimized. What kind of strategy is used to minimize truck traffic generated in you facility?

(6) Do you use any type of e-commerce such as telephone order and internet? How does it affect your business?