

**DATA NEED FOR TRUCK TRIP GENERATION  
ANALYSIS: QUALITATIVE ANALYSIS OF THE SURVEY  
OF RETAIL STORES**

By

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## **ABSTRACT**

The information on truck movements is important for planners, policy makers, and citizens to create a plan for new commercial or industrial facilities and transportation infrastructure improvements for their community. While considerable strides have been made in forecasting truck travel demand in the past several years, there remain three critical gaps that need to be addressed. First, data collection efforts in the public sector have been limited. Second, the lack of the data has limited the existing truck trip generation (TTG) models to the spatially aggregated level. Third, due to the aggregate nature of most existing models, they are not suited for analyzing the impacts of the changes related to the supply chain management strategies such as the transformation from push- to pull-logistics.

To address these gaps, this research strives to improve the methodology for TTG by using the business data at the disaggregate level. The basic premise of this modeling approach is that TTG is measured and predicted better at the individual business level and should be summed up to produce a spatially aggregated TTG. As a first step toward a methodological improvement, this paper tries to understand the patterns of truck deliveries between distribution centers (DCs) and retail stores in the Midwestern states. The data for this research come from the routing and replenishment schedule between DCs and the stores obtained from five furniture chains and four shoe chains.

To begin with, the paper review the past studies on TTG and propose a new framework. Then, the data collection strategies are discussed. After the discussion on the collected data, the findings and implications for the further research conclude this paper.

## **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.

This paper reports the experiences and preliminary findings 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 TTG, the discussion is followed by the summary of the literature regarding TTG models used in past studies. Third, 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. Fourth, the strategy for data collection is fully addressed, since it is the most critical and yet most difficult part of the research. Before the concluding remarks, preliminary findings from the collected data and implication of the paper to the future research are discussed.

## **RECENT TRENDS:**

There have been several driving forces that have led transportation professionals 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 21<sup>st</sup> 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, available estimates predict rapid growth of goods movements by trucks over the next two decades. Finally, changes in the goods movement behavior may lead to 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 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-sector data bases like TRANSEARCH, the price of the data limits the extensive use of the data in many regions.

Because of these reasons, the existing models for TTG (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 present 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 of an individual business (Wilson, 1980)” that is responsive to the consumer demand. The businesses strive to increase profit by reducing the cost of supply chain management as much 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’ strategic decisions and resulting activities. We argue that by examining the detailed data at the individual business level, it will be possible to find out the variable that will accurately estimate the number of truck trips generated. The goal of the paper is to review the issues of past and current truck travel forecasting models, suggest a new framework for TTG, 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 the findings from the qualitative analysis of the surveyed data
- (6) Provide suggestions 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 the tonnage of commodity flow and then converts it to the number truck trips. By contrast, the trip-based approach directly estimates the number of truck trips. However, a 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 at site-by-site basis, while the commodity-based approach is applied at the zonal or regional level. Since the zonal-level economic data are relatively easier to obtain compared against the site-level information, the commodity-based approach is the one that is more frequently used in practice if the goal of a study is to forecast area-wide truck trips.

Although the commodity-based approach has been extensively studied, it can underestimate 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 from the trip-based approach.

## **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 was a good measure for a short-term plan for a small study area. This method is probably the simplest and most straightforward. However, the results calculated from the trip rate based on a single independent variable “vary highly from one region to another and within region (Fisher & Han, 2001).”

### *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 conducted 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 et al. (2000) estimated the number truck trips as a function of imported and exported containers at the Port of Miami, Florida.

Methodologically, the process of regression analysis is straightforward and its properties are well-understood. However, the most models used in the past studies utilized observable data that only show the proxies of freight activities at a study region. Except for a site-specific study at ports (Al-Deek et al, 2000; Holguin-Veras and Lopez-Genao, 2002), most studies used the variables that were spatially aggregated. Consequently, the changes at the individual business levels could not be captured. Furthermore, the models developed for a site-level analysis have showed a high level of transferability. 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 transferable model structure than spatially aggregated models.

### *Trip Matrix Estimation*

Although the trip matrix estimation has been an area of research for some time, the application to freight travel demand modeling 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.

List and Turnquist's study showed that if detailed data for trip matrices are available, it is possible to produce a relatively accurate estimate of truck 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 discuss 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 the complex relationships between dependent variables and independent variables. However, the major disadvantages of the 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 for the simulation, computational burden, and the requirements for the detailed data (Al-Deek, 2001; Klodzinski & Al-Deek, 2003).

#### *Behavioral Approach*

Over the years, the focus of the research on TTG 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 TTG. Such characteristics are reflected well in the 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 a “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 interactions 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 traditional four-step travel forecasting model to supply chain, which takes a form of a mid-scale model between zonal-base four step model and disaggregated logistics models. Although the model has not been mathematically constructed yet, it should provide 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 shipments 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 TTG.

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 purpose since the trip rates based on land area (e.g. floor space, foot print, etc.) 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 TTG. 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**

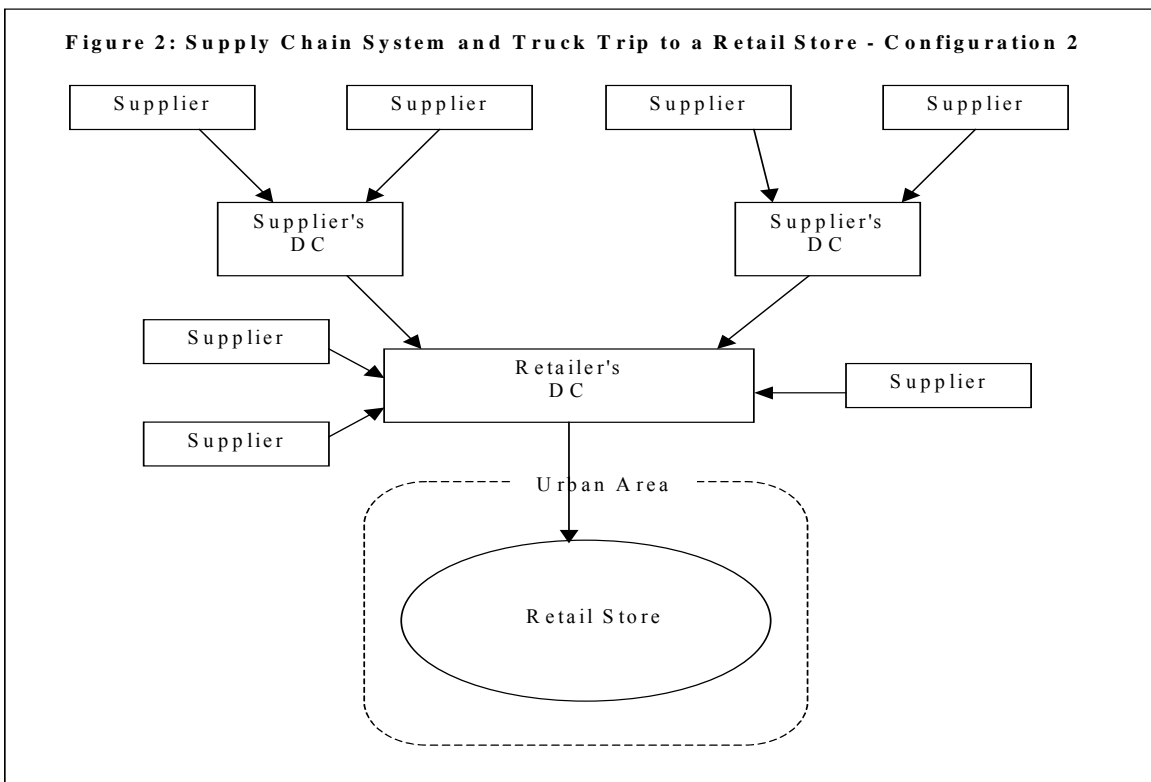
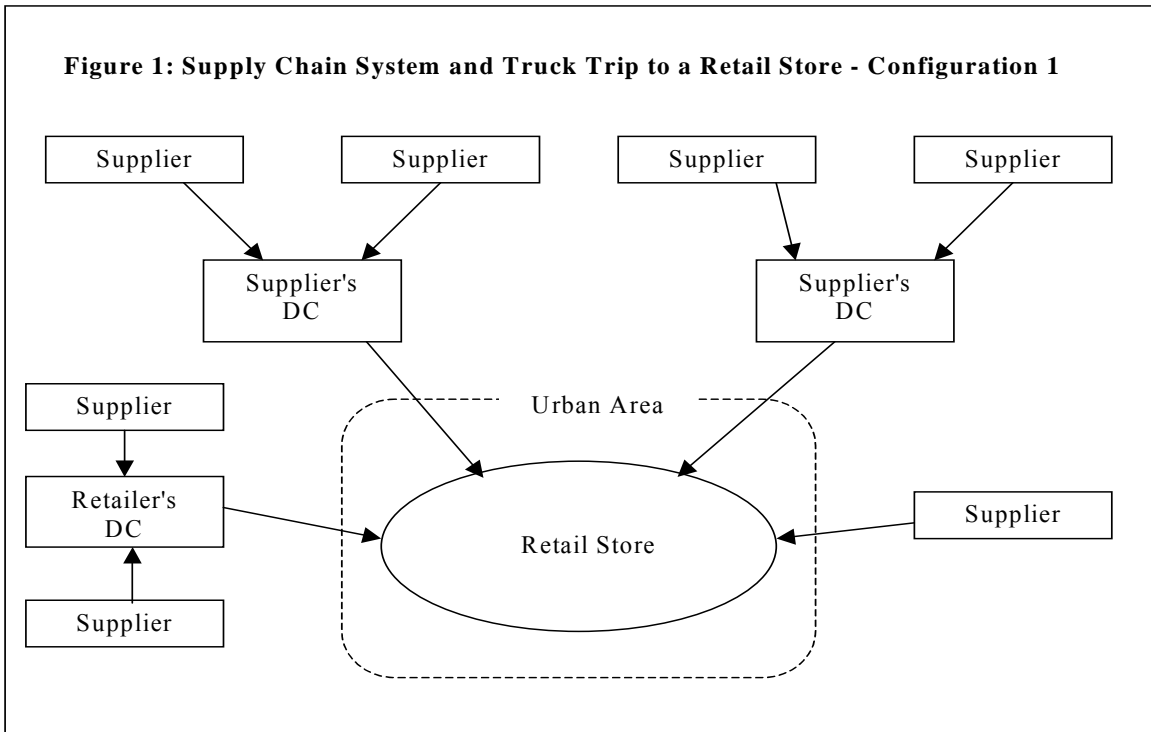
### **Framing the issues**

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.*

Analysis at the large geographical level implicitly ignores heterogeneity in the characteristics of businesses in a study area. While in reality, 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 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 for some industries, 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.



## **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 TTG, 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, 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 two assumptions:

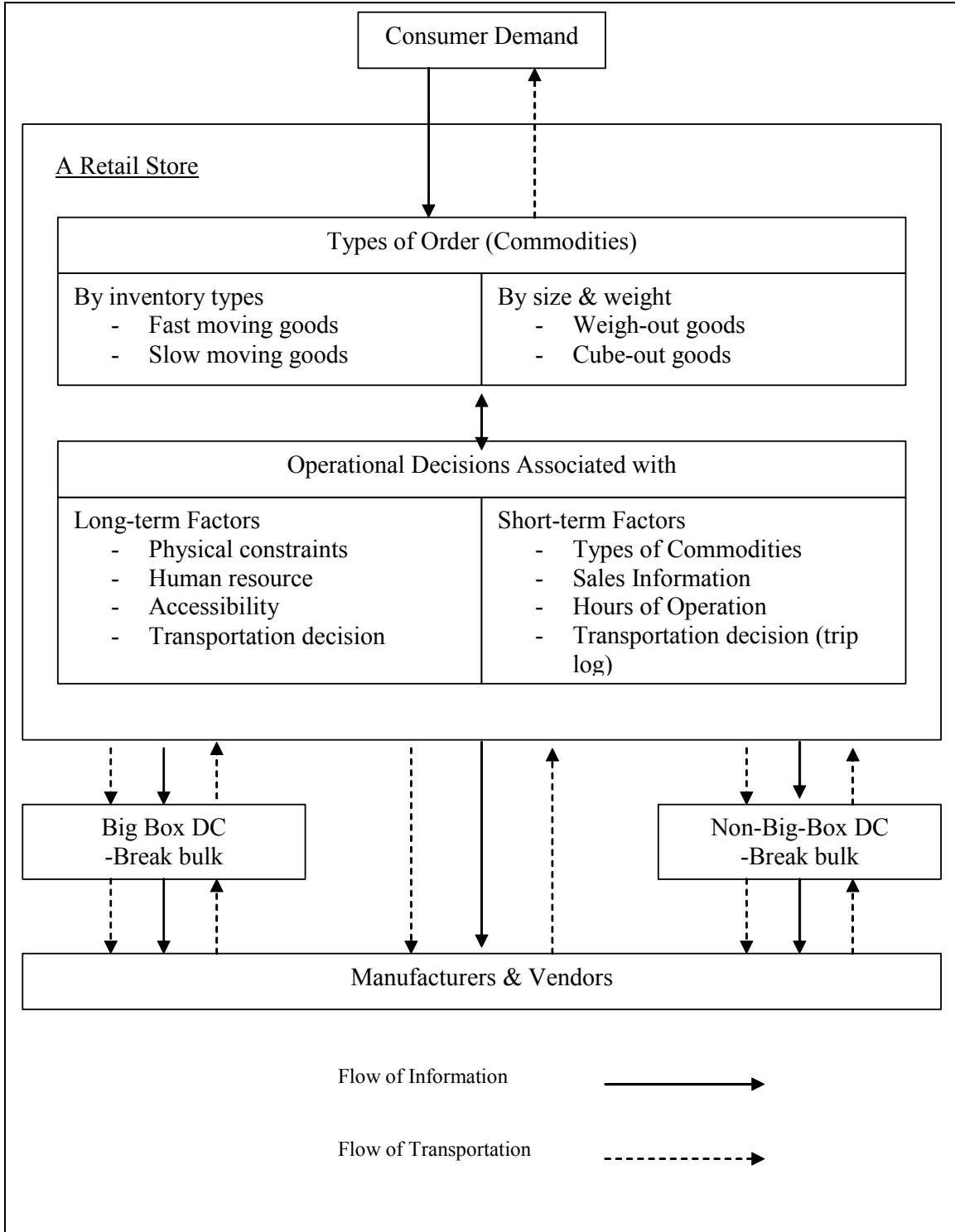
- (1) *The number of truck trips is directly related to the activities of individual facilities in a supply chain where the strategies and actions may depend on the unique circumstances in order to maximize a facility's efficiency and profit by minimizing cost.*
- (2) *Types of goods traded in the DCs 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. In other words, the stores in the similar business sectors may have similar TTG characteristics.*

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. 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.

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.

**Figure 3. Conceptual Framework of TTG**



## **DATA COLLECTION STRATEGY**

In the previous sections, the problems with the aggregate TTG models have been identified and a new research framework has been proposed. However, the real challenging part of any model development is the collection 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 distribution centers (DCs) and retail stores have been selected as focal groups of interest.

#### **(2) Creating Contact Information**

Considering the amount of resources available for data collection, it was decided that the data would be obtained from the DCs and retail stores in the Midwestern states. 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 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, the phone numbers and e-mail addresses were collected. 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. Once the businesses agreed to participate in the survey, the wish list was sent to the contacts 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 the 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.

### **Conducting Survey: Two-Step Approach**

The data collection was conducted with a two-step approach. The first approach used the contact list and the data wish list. After the first round of contacts, the second approach – “store visit” and “phone survey on individual stores” – were conducted. Two approaches were used in order to complement each other. The survey result is summarized in Table 1.

#### *Distributing Questionnaire: Contact List and Data Wish List Approach*

Once the contact list and the data wish list were created, several rounds of phone calls were made. Each company was contacted 3-5 times since it was difficult to talk to the person directly. Mostly, the potential interviewees were out of office. In some cases, a secretary screened a phone call. About 50% (37 in 75) of contacted companies agreed to review the data wish list. As seen in Table 1, we obtained the data from the three different retail companies (Furniture chain A, Shoe chain A, and Apparel chain A). The response rate was extremely low at only 4%.

The advantage of this strategy is that much detailed information can be obtained from the interviewees. For example, the research team visited the DC of Furniture chain A. The DC covers 76 stores in 18 states in the Midwestern and Eastern states. In addition to routing information for a typical week, a day-long meeting provided the research team with valuable insights on the operations of interviewee’s company and other DCs in a similar sector. In addition to the furniture store, Shoe chain A provided the routing information for a year 2004 of 259 stores in 24 states.

Despite such advantage, several weaknesses prevented the research team from pursuing this strategy. First, 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 along did not guarantee that the initial contact was the right person. Often an interviewer was referred to different individuals or departments within the company. Second, much of the information included in the questionnaire 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 delay and an extremely low response rate. For example, it took 4 and half months to receive a data file from Shoe chain A. Shoe chain A was in the middle of a high demand season; and there were several heavy snow storms that disturbed their shipment schedule. Third, 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. Fourth, the units of measuring the inventory flows (Furniture chain A, Shoe chain A, and Apparel chain A) are different.

This resulted in no consistent information. For example, the important information to Furniture chain A is the number of pallets delivered to each store. On the other hand, the number of cartons per each store is the most important information for Shoe chain A. Since Apparel chain A only provided an aggregated information (average per store information), the data from this chain was discarded. Fifth, detailed information that we hoped to obtain in the TTG framework in Figure 3 is not easy to collect. So, the research team should make much compromise with the reality.

#### *Store Visit and Phone Survey of Individual Stores*

The difficulties of collecting data by distributing a survey questionnaire, the research team decided to visit some stores and also make phone calls to individual stores. The purpose of this approach was to complement and verify if the stores in the same sector receive the similar number of weekly deliveries. In addition, the data points can be used to test the performance of the TTG model that will be developed based on the detailed information collected from three original respondents. Thus, the competitors of Furniture chain A and Shoe chain A were found from the websites of Hoovers ([www.hoovers.com](http://www.hoovers.com)) and Investors Words ([www.investorwords.com](http://www.investorwords.com)). These are the Internet firms that sell business information to investors. The information on the brief introduction of firms and competitors is available at no cost. Furniture chain A has four competitors (chain B, C, D, and E). Three competitors (chain B, C, D) of Shoe chain A were identified. The addresses and phone numbers of stores based in Chicago area were collected from the websites of stores.

A 200-mile-survey trip covered 16 stores in the area. While the response rate of 100 percent was encouraging, most store employees or managers did not want to divulge the details of their business activities. In addition, it was resource consuming method (e.g. time and cost). By contrast, the phone call survey proved to be quite cost efficient. A total of 120 stores were called. The overall response rate was very high at 60% (72 stores).

Nevertheless, this strategy encountered various problems while collecting detailed information. First, most employees did not have detailed information on store operations. Second, even if they knew the details, they were reluctant to reveal any information. Third, sometimes, an employee referred the interviewer to a store manager. In this case, it was almost impossible to obtain information.

**Table 1. Survey Result**

Strategy	Chains	SIC*	Response Rate	Numer of Stores	Advantage	Disadvantage
Distributing Survey Questionnaire to Distribution	Furniture A	5712	4% (3/75)	76	* Detailed replenishment schedule with routing plan	* Extremely low response rate * Time consuming * No consistent information
	Shoe A	5661		259		
	Apparel A	5632		n/a		
	Subtotal			<b>335</b>		
Visiting Stores	Furniture B	2511	100% (4/4)	4	* Cooperative	* No detail information * Time consuming
	Furniture C	5719	100% (6/6)	6		
	Furniture D	2512	110% (6/6)	12		
	Subtotal		100% (16/16)	<b>22</b>		
Phone Survey (Individual Stores)	Furniture E	5719	44.4% (16/36)	16	* Somewhat responsive * Low cost	* No detail information
	Shoe B	5661	67.5% (27/40)	27		
	Shoe C	5661	50% (10/20)	10		
	Shoe d	3149	79.2% (19/24)	19		
	Subtotal		60% (72/120)	<b>72</b>		
<b>Total</b>				<b>429</b>		

\* The definitions of 4-digit SIC

- 5712 - Furniture Stores
- 5719 - Miscellaneous Home Furnishings Stores
- 2511 - Wood Household Furniture, except upholstered
- 2512 - Wood Household Furniture, upholster
- 5661 - Shoe Stores
- 3149 - Footwear, Except Rubber, Not Elsewhere Classified

## **SURVEY RESULT: FINDINGS**

This section discusses the findings from the preliminary analysis of the surveyed data. Although the number of retail chains in the sample is below the research team's expectation, it is possible to make several insightful observations that would be the foundation for further research.

*First, all surveyed retailers have highly standardized routing schedule all the year round, supporting a basic assumption of this study, "strategic and operational decisions of individual business activities in a supply chain are closely related to TTG."* In Table 2, except for Furniture chains A and E, other seven chains have the same number of deliveries throughout the year. On the other hand, with Furniture chains A and E, some stores receive only one delivery per week while others receive two deliveries per week. Such standardization can be possible by consolidating and distributing all items in a company owned DC, which is similar to the system depicted in Figure 2.

*Second, the size of store and the number of employment may not explain the TTG of the furniture stores.* Except for Furniture chain A, all the furniture chains in the data



set do not deliver furniture to their store for customer pickup. Customer deliveries are made directly from their DCs to the customers. In this way, the stores can minimize the inventory. In addition, they can reduce the number of deliveries to the store, and also keep the personnel and space small enough for showroom purposes. For example, the DC of Furniture chain D that covers 13 stores delivers 1200-1400 items every week to customers.

*Third, standard industrial classification (SIC) number is not a reliable scheme to categorize the businesses, which makes it difficult to estimate TTG by industry.* Especially, this is the case in furniture stores (Table 2). Only two of five stores are reported as competitors have the same 4-digit SIC numbers. Moreover, Shoe chain D is assigned to SIC 3149, which is a subcategory for manufacturers.

**Table 2. The Number of Weely Deliveries per Store**

	Chains	Number of Deliveries	Truck Types	Coverage per routing	SIC
Furniture	A	1 or 2	Semi	2-4 stores	5712
	B	1	Semi	n/a	2511
	C	5	UPS	n/a	5719
	D	1	Semi	n/a	2512
	E	1 or 2	Semi	n/a	5719
Shoe	A	1	Semi	3-5 stores	5611
	B	2	Semi	n/a	5611
	C	1	Semi	n/a	5611
	D	1	Semi	n/a	3149

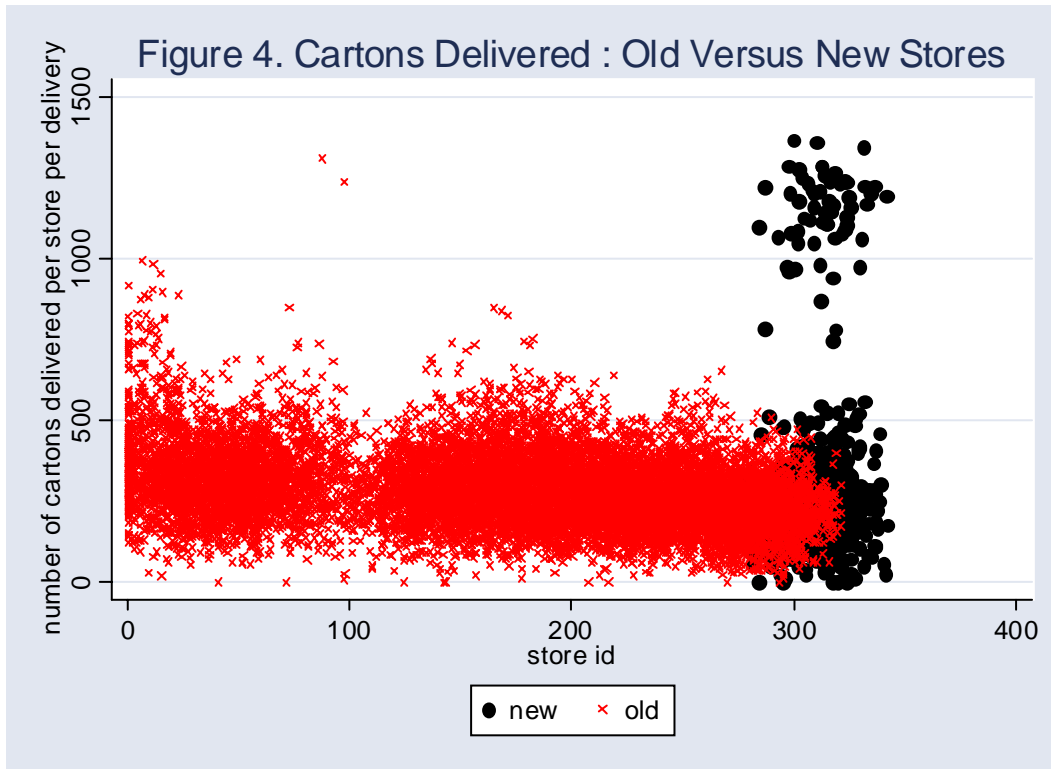
*Fourth, the effects of the shift from push to pull-logistics are found in Furniture chain C.* As seen in Table 2, all stores of this chain receive daily parcel shipments between Monday and Friday. We were informed that the chain C recently changed from the previous replenishment schedule of two weekly shipments by semi-tractor trailers. The purpose of the change is to quickly respond to a changing consumer demand.

*Fifth, the variation across the stores in the same chain looks similar, which may implies the standardized routing and replenishment plan.* The variation of the number of cartons delivered to Shoe chain A is large (Table 3). However, the second and third columns of Table 3 indicate that the variation is reduced when only old stores are considered. Figure 4 clearly displays such variations by stores. New stores (black dots) are divided into two extremes. However, old stores (red color) are within certain range with the existence of outliers.

*Sixth, the seasonal variation of the number of cartons is observed.* As shown in Figure 4, the seasonality of the number of cartons is observed. It seems that this chain has three high demand seasons: Spring back-to-school, Summer back-to-school, and Christmas. This figure raises one question: *how does the chain manage to operate with once-a-week delivery, despite the seasonal variation in the sales?* This question should be answered in the future research.

**Table 3. Summary Statistics for Shoe A**

	all stores	Old	New
Number	259	237	22
Mean	285.96	283.95	322.26
S.D.	116.95	98.37	289.09



*Seventh, the location/site characteristics or store types may explain the pattern of truck trips.* The data from Furniture chain A provides another interesting insight into delivery patterns, which is shown in Table 4. Stores are classified into three types by location characteristics – mall based stores, off-mall based stores, and outlet stores. As such, stores are divided into three classifications depending on the type of items sold – conventional, "combo," and outlet. The conventional stores deal with furniture for adults. The combo stores sell furniture for both adults and kids. Outlets sell out-of-dated items at the discounted prices. The trend for this chain is that the stores are moving to "off-mall" (e.g. strip mall) locations because of the convenient truck access to the store and spacious floor space that allows for attractive displays that are more attractive to customers (relative to the mall based stores). In addition, the newest stores are all "combo" stores. The importance of location and store characteristics stems from the observation that the number of delivery and the number of pallets per delivery seem to have some association with those characteristics.

In the same table, fifty one stores receive one delivery per week and 18 stores receive two deliveries per week. The stores receiving weekly delivery have more pallets per delivery than the stores receiving two-per-week deliveries. Newer off-mall stores and combo stores tend to receive two deliveries per week. This may be related to the size of the store. As mentioned previously, the off-mall stores tend to be larger than the mall stores. We were informed that the off-mall stores generally have higher sales volumes than the mall stores. Most mall based stores or conventional type of stores receive one delivery per week, supporting the trend toward off-mall base bigger stores, again.

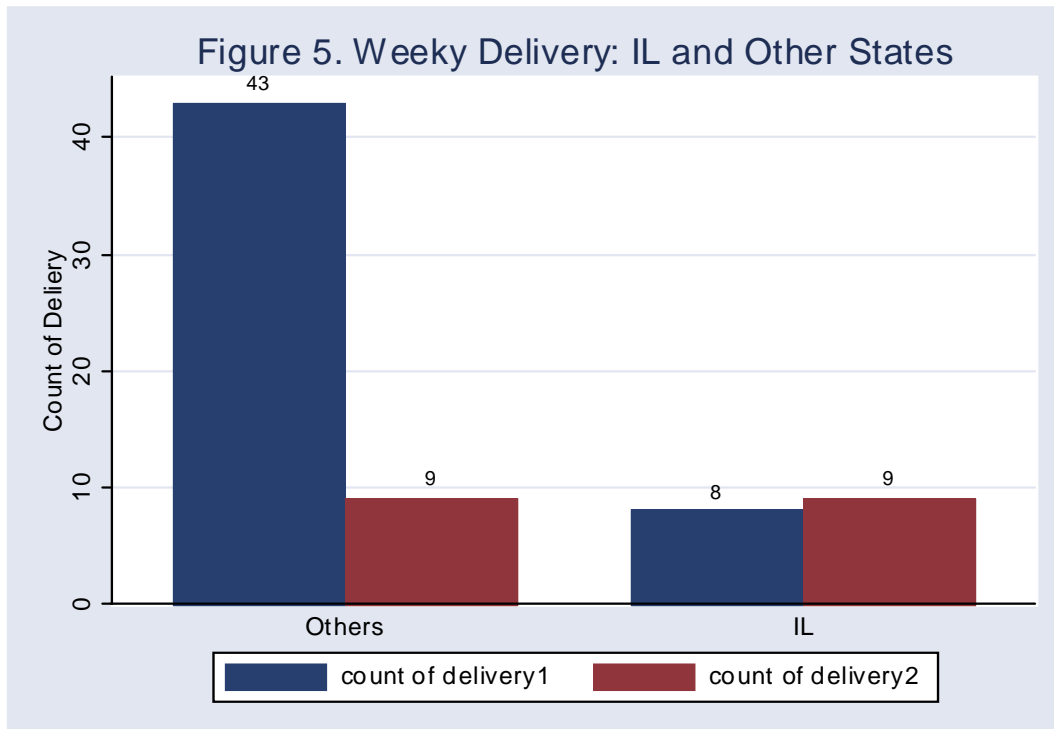
*Eighth, socio-economic characteristics may explain the differences in delivery patterns of Furniture chain A. Figure 5 divides the sample into the stores in Illinois and other states. Interestingly, more stores in Illinois received deliveries twice a week, while the majority of stores in other states had one delivery per week. As a populated state with the third largest city in the United States, Chicago – in terms of population, there is a bigger demand base. The analysis of the delivery pattern as a function of various socio economic variables may yield an interesting result.*

**Table 4. Delivery Patterns by**

By Location Characteristics									
	Mall			Off-mall			Outlet		
Delivery/Week	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
1	28	8.71	1.96	15	9.47	2.64	8	11.88	2.7
2	6	8.33	1.86	10	7.2	3.8	2	9.5	0.71
Total	34	8.65	1.92	25	8.56	3.28	10	11.4	2.59

By Store Characteristics									
	Combo			Conventional			Outlet		
Delivery/Week	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
1	1	7	n/a	42	9.02	2.23	8	11.88	2.7
2	9	6	1.73	7	7.2	3.5	2	9.5	0.71
Total	10	6.1	1.63	49	9.12	2.41	10	11.4	2.59



## **IMPLICATIONS FOR FURTHER STUDY**

So far, some comparisons based on the visual inspection and simple descriptive statistics have been conducted. Although a more in-depth analysis should be made, the qualitative observations discussed in the previous section should play important roles in designing future studies. The most important preliminary findings of this study is: *“Although consumer demand (as sales volume), and socio-economic characteristics (consumer base) are probably important factors of deciding the number of items to retail stores, the businesses in the sample manage to keep regular replenishment schedule all the year round.”* In this sense, the paper produces several recommendations and expectations for the next stage of the study.

(1) The study should recognize the direct impacts of 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 should have similar patterns of trip generation.

(2) The variables identified in the future 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) Long term impacts associated with the new trends, such as City Logistics, E-Commerce and the just-in-time logistics system, maybe understood from an in-depth research. 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**

In this paper, the problems associated with the existing models of TTG were reviewed. Also, 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 the experts in logistics and supply chain management. The findings from the survey seem to provide some indication that the assumption of the study on the firm behavior is a critical factor. In addition, the findings suggest that the independent variables used in past studies may not be appropriate for the disaggregate level of TTG.

Despite these findings, the several difficulties remain as barriers.

The first and foremost issue with TTG is data availability. In most cases, private businesses consider the information related to the business activities proprietary. It is a good strategy for a researcher to emphasize to the participants the tangible benefits that

can be generated from the outcome of the study. However, it is not an easy task to provide concrete examples of advantages to entice the businesses to participate.

The second issue involves the types of independent variables. For a more comprehensive study of TTG and to find a more reliable 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.

The third issue is the selection of the businesses to be included in the study. The study should begin with the 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, Shoe chain A has only one DC in the Midwest region that serves all the retail stores (over 250) in the U.S. Shoe chain B 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.

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