

# Understanding and Modeling Freight Stakeholder Behavior

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# UNDERSTANDING AND MODELING FREIGHT STAKEHOLDER BEHAVIOR

Project CFIRE 02-06  
April 2012

Final Report

National Center for Freight & Infrastructure Research & Education  
College of Engineering  
Department of Civil and Environmental Engineering  
University of Wisconsin, Madison

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16. Abstract  This project developed a conceptual model of private-sector freight stakeholder decisions and interactions for forecasting freight demands in response to key policy variables. Using East Central Wisconsin as a study area, empirical models were developed for selected elements of this conceptual model that are fundamentally significant to the production/attraction, spatial distribution, and modal split of freight movements. The empirical results formulated the recommendations to the East Central Wisconsin Regional Planning Commission (ECWRPC) on freight planning and demand model enhancement.			
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# CHAPTER 1. INTRODUCTION

## 1.1 Background

Effective freight transportation planning and programming for sustainability and other community goals requires the means to accurately forecast the response of freight pattern to infrastructure improvements, demand management strategies, and traffic control measures. The need for reliable freight demand forecasting procedures has also received a major impetus because of the legislative requirements on mobile-source emissions and the importance of freight mobility to the nation's economic competitiveness.

Today, most ongoing statewide and urban area freight planning processes adapt the growth factor method or the trip-/commodity-based four-step modeling (production/attraction, distribution, modal split and assignment) approach, originally developed for passenger transport. Yet, development in freight demand forecasting has clearly lagged behind that in the passenger demand forecasting, despite the critical role of freight transportation in the overall transportation planning process. In the passenger transportation arena, there has been a shift in demand modeling paradigm from the trip-based, four-step approach to the activity-based approach that gives emphasis to the activity and travel behavior of individuals. This shift in modeling approach is driven by the growing recognition that, while the four-step approach is capable of evaluating impacts of long-term capital improvement strategies, it falls short in its ability to realistically represent travelers' response to short-term congestion management policies such as ridesharing incentives, congestion pricing, and work hour staggering. The inadequacy of the four-step modeling approach is further exposed as planning agencies look to the various intelligent transportation systems (ITS) initiatives as potential solutions to our transportation related problems. Again, this is because four-step models are not well equipped to represent the behavioral impacts of time savings and improved temporal freedom due to technology use and information provision. The need to better model the impacts of new policy actions had led to the emergence of the activity-based approach to passenger travel demand modeling, which views travel as a derived demand from the need to pursue activities distributed in space.

Similar to passenger travel demand, the demand for freight movement is also a derived demand. That is, commodities do not receive satisfaction from being transported. Rather, they are transported across the supply chain as a result of economic activities such as production, consumption, and sales. Given the lessons learnt from the passenger travel arena, researchers are beginning to incorporate behavioral paradigms into freight demand models. The challenge underlying the developing of behaviorally oriented freight demand arises from the multiplicity of freight decision-makers, including shippers (suppliers), receivers (consumers), carriers, consignees, and third party logistics providers (3PLs) (Hutchinson, 1985). Each decision-maker has different objectives, decision power, knowledge, and perceptions about supply chain and transport related choices. They also interact with each other in intricate ways throughout the supply chains. A clear understanding of how stakeholders make decisions in their different roles regarding goods movement and of how they interact with each other is therefore a critical prerequisite to behaviorally-sound freight demand modeling and reliable policy analysis.

To date, the literature in logistics and management science provides some insight into trends or changes in supply chain relationships, technology adoption, or procurement strategies.

Unfortunately, they are not very useful from the freight modeler point of view since they provide little insight into how the knowledge can be translated into parameters of demand forecasting models (Figliozi, 2006). Quantitative analysis of freight stakeholders' decision-making processes tend to focus on specific behavioral aspects. It is only very recently that more comprehensive freight models capable of incorporating supply chain concepts began to emerge. Yet, the behavioral elements and realism in these models remain limited. A main reason is the limited availability of the 'right' data to support investigation of stakeholder behavior at individual decision-makers' level and to help address pertinent freight issues. Some of the pressing and emerging issues that motivate the need for better understanding of freight decision processes are (Mahmassani, 2001):

- the impacts of e-commerce on logistics and in turn on transportation planning and operations;
- the growing desire of using inter-modalism as a strategy to attain many of our sustainability-related goals;
- the question of how firm location decisions relate to business activity patterns, and how this interaction may in turn influence and be influenced by the surrounding land use development;
- the impacts of truck vehicle size and weight regulations on the infrastructure and the environment; and
- the energy (in)efficiency of current freight travel pattern and the effectiveness of counter-measures.

These issues drive the present inquiry into freight stakeholder behavior and the development of next generation freight demand models.

## 1.2 Research Objectives

The primary goal of this project is to gain a deeper understating of freight decision-making processes and of the interaction among private stakeholders so as to inform the development of policy-sensitive freight demand forecasting models. The specific research objectives are:

### 1. To develop a new conceptual and modeling framework for analyzing freight stakeholder decision-making processes and for forecasting freight demands in response to key policy variables.

The proposed framework is intended to incorporate supply chain concepts, bridge the existing body of literature, and advance the state-of-the-art in freight modeling. It outlines *who* decide on *what* aspects of freight movement and *how* does the decision relate to *which* policy/design variable. The framework is to be used as a conceptual model to guide the analytical component of the present study and the future development of freight behavioral theories and models.

### 2. To develop recommendations on ways of enhancing and verifying East Central Wisconsin Regional Planning Commission's current freight demand model.

As a partner in this project, the East Central Wisconsin Regional Planning Commission (ECWRPC) is particularly interested in how the understanding of freight stakeholder

behavior gained from this study could help inform the future development of their freight model, which follows the conventional four-step structure.

**3. To conduct empirical analysis of selected logistics decisions and commodity sectors, identify the underlying behavioral determinants, and make policy/investment recommendations.**

Clearly, it is not possible for any single study with limited resources to analyze all freight-related decision dimensions in any thorough manner. Based on the data collected and knowledge developed along the way, the research team and the project's oversight committee have chosen to focus the empirical component of this study on shipment/trip frequency. As logistics decisions are likely to differ by commodities, this study focuses on the manufacturing industry, which has the most impact to the overall freight movement in northeast Wisconsin. The data collection and analysis efforts are also intended to help accomplish Objective 2.

### **1.3 Study Components**

This study entails performing the following tasks to achieve the above listed objectives:

**Task 1. Review the literature on behavioral analysis of freight stakeholders as well as on logistic and transportation decision-making.** This entails synthesizing the existing literature pertaining to the logistic and transportation activities and decisions that materialize into freight demand. The synthesis provides a summary of earlier studies in terms of their behavioral and logistic aspects examined, behavioral principles assumed/identified, methodological structure, data source, and study area.

**Task 2. Develop a representation framework of private-sector freight stakeholder activities and goods movement decisions.** Based on the literature synthesis from task 1 and the research team's knowledge base, a comprehensive representation framework is developed to capture the decision dimensions of, and interactions among, freight stakeholders. The framework defines the choice dimensions and locus of decision-making most relevant to freight planning concerns and demand forecasting needs at the regional and urban levels. The framework includes decisions ranging from production/consumption decisions, to supply chain and inventory replenishment, shipment origin, destination, content, timing, quantity, mode, and routing decisions.

**Task 3. Conduct interviews and focus group to verify and enrich the representation framework.** Through in-depth face-to-face interviews with private-sector stakeholders, the representation framework developed in Task 2 is verified and enhanced to add details and behavioral realism. Interview instruments including an extensive questionnaire were developed as part of this task.

**Task 4. Evaluate ECWRCP model and develop data collection recommendations.** This task focuses on evaluating ECWRPC's current freight model (referred to as the NE Model) and identifying possible ways of utilizing this study's findings to enhance the NE Model. The data sets identified and collected in Task 4 are assessed in terms of their usefulness in enhancing the NE model. Recommendations are also made regarding what additional data collection efforts would be needed for accomplishing our proposed enhancement to the NE Model.

**Task 5. Identify the data needs and review available data sources for modeling logistic decisions of freight stakeholders.** It is well recognized that developing a freight demand forecasting model based on the framework outlined in Tasks 2 and 3 would require a lot more data than what is available today. This task identifies the needs and availability of data for conducting qualitative and quantitative analysis of stakeholder logistics decisions. Data sets available for the east central Wisconsin region are collected and reviewed as part of this task to determine the extent to which the proposed modeling framework could be estimated.

**Task 6. Design and administer an establishment survey.** The survey collects information regarding basic firm characteristics, commodity type and weight received/supplied, locations and characteristics of customers, shipping frequency/time, and transportation services used. The survey is designed with two objectives. First, enhance our current understanding of the dynamics in freight shipping patterns. Second, help verify or improve the NE Model's goodness-of-fit and behavioral realism.

**Task 7. Conduct empirical analysis.** This entails data exploration and cleaning to ensure data consistency, data processing to obtain relevant variables of interest, and data assembly to bring together all relevant data and structure the data in a format suitable for analysis.

## **1.4 Report Outline**

The remainder of the report is organized as follows. Chapter 2 highlights findings from the literature review conducted as part of Task 1 of this study. Chapter 3 describes the work performed under Tasks 2 and 3 of the study, including an outline of the initial conceptual framework, the face-to-face interviews conducted to gain more insight into freight stakeholder behavior, a discussion on intra-firm interdependency, and description of the proposed firm-based modeling framework. Chapter 4 describes the work performed for Task 4, which entails assessing the freight transportation component of version 11 of the Wisconsin Northeast (NE) Region Model. The chapter documents the research team's understanding of the NE model structure, discusses the model's strengths and limitations, and concludes with the research team's recommendations on ways to further improve the model. Chapter 5 describes the data synthesis conducted as part of Task 5 of this study to identify the needs and availability of data for conducting qualitative and quantitative analysis of stakeholder logistics decisions. It also presents the design and pretest of a mail-out-mail-back survey of business establishments, as well as a telephone survey targeting at manufacturers in Brown County, WI. These surveys constitute Task 6 of the study. Chapter 6 reports the two major pieces of empirical analysis conducted for Task 7. The first piece of analysis is based on the proprietary InfoUSA business database. The second piece of analysis is based on telephone survey data of manufacturers. Finally, Chapter 7 summarizes the study accomplishments and discusses their implications.

## CHAPTER 2. LITERATURE REVIEW

This chapter highlights findings from the literature review conducted as part of Task 1 of this study. The existing literature in logistics and management sciences pertaining to freight stakeholders' decision-making is abundant. While this body of literature provides insights into the behavior of freight stakeholders, knowledge in these areas is not yet well translated into freight demand modeling efforts. To date, only limited studies have attempted to incorporate logistics elements in their modeling of either specific freight-related decision dimensions or overall freight movements. This literature synthesis focuses on recent development of comprehensive micro-level models of freight movement. These past studies are comparable in scale to the model development effort set out in this project (Objective 1). Other studies reviewed as part of this study, but focus only on specific logistic/transportation choice dimensions, are discussed mostly in CHAPTER 3 of the report.

Hunt and Stefan (2007) construct an urban commercial vehicle movement micro-simulation model using establishment-based survey data collected in Alberta, Canada. The micro-simulation procedure starts with determining the number of tours at each establishment. Their differential treatment by industry type allows an establishment's role in the supply chain to impact its tour generation pattern. The complete tour of an individual vehicle is then created by sequentially simulating each stop purpose and location. By modeling vehicle tours explicitly, the authors avoid the need to consider issues typically associated a commodity-based approach, issues such as commodity-to-truck conversion and empty trips. Owing to the same reason, however, the logistics decision-making process is also hidden.

Instead of modeling each vehicle, Wisetjindawat et al. (2007) develop a micro-simulation model that considers each freight agent individually. Commodity consumptions and productions are generated for each establishment using linear regression models that incorporate variables such as commodity type, employment size and facility size. Next, commodity flows between consumption and production points are determined through customers' purchasing choice, which is modeled as the product of distribution channel probability, shipper location probability, and supplier selection probability. Commodity flows are then converted to freight flows through the shipment size, vehicle choice, and routing models.

The lack of disaggregated data at establishment level and heavy computational burden impede the development and implementation of micro-simulation model. In order to overcome these difficulties, Samimi et al. (2010) propose a freight modeling framework - Freight Activity Microsimulation Estimator (FAME), in which establishments with similar location, industry type and establishment size are aggregated into a firm type. And this firm type is used as an analysis unit in other succeeding model components, including supplier selection, shipment size determination, mode choice, traffic assignment, and so on.

Boerkamps et al. (2000) present a conceptual framework that explicitly describes the markets in which different agents interact. These markets include commodity market, transport services market, traffic services market, and infrastructure market. This market-based framework provides guidelines for the development of the GoodTrip model, which is a consumer demand-driven freight movement model.

The difficulty of representing the shipments of mixed goods is known as one weakness of commodity-based freight models. Fischer et al. (2005) propose an integrated modeling framework to address this issue by combining the logistics chain commodity-based approach and the truck tour-based approach. In order to apply the framework, the authors also identify a typology of freight movements as consisting of four categories: domestic freight, warehouse and distribution, local delivery, and service. Fischer et al. (2005) suggest that the logistics chain approach is better suited for modeling domestic freight and warehouse and distribution movement because these two types of freight are usually associated with large shipments of single type of commodities. In contrast, the tour-based approach is recommended for modeling local delivery and service types of freight movement as these movements have multi-stops and loads of mixed goods.

Liedtke (2009) develops an agent-based commodity transport model, INTERLOG, at the national level. Through micro-simulation, the commodity flows throughout two types of actors, namely freight needs-generating firms and transport forwarders, are determined. The model consists of three modules: (1) agent generation module for generating firms (factories and wholesalers) and forwarders, (2) sourcing module to establish supplier-recipient relationships and determine the demand for commodities, and (3) market interaction module for translating good flows into shipments, allocating transportation contracts to forwarders, and constructing truck tours. One interesting feature of this model is that it explicitly considers freight forwarder as an agent and models its interaction with shippers based on a learning process. However, the model doesn't explicitly consider the roles of warehouse and distribution center and therefore omits the goods exchange and the corresponding vehicle movements involving these facilities.

Similar to Liedtke (2009), Roorda et al. (2010) also consider the diversity of roles in the freight system and propose a conceptual framework to model freight transportation demand. The framework focuses on representing contracts for goods procurement among establishments. Once production, consumption and order quantities of business establishments are determined, commodity distribution is obtained through a market interaction procedure, in which establishments advertise products in market and customers select suppliers based on the random utility maximization principle. While Roorda et al. (2010) acknowledge the presence of multi-establishment firms, they adopt the simplifying assumption that establishments behavior independently and intra-firm interdependency is considered for only logistics facilities. In fact, the assumption of independency among establishments of the same firm is an assumption adopted by most agent-based freight demand models developed to date.



## CHAPTER 3. PROPOSED FRAMEWORK OF FREIGHT BEHAVIOR

This chapter describes the work performed under Tasks 2 and 3 of the study. Specifically, Section 3.1 presents the initial conceptual framework developed in Task 2 that represents all elements of logistics management driving a firm's freight transportation demand. Section 3.2 describes the face-to-face interviews designed and conducted to gain in-depth understanding on certain aspects of freight stakeholder behavior. Based on the knowledge gained from the interviews, the research team identified that intra-firm dependency in logistic decision-making is an area of research needing much more attention. Section 3.3 is devoted to a discussion of the intra-firm interaction phenomenon. Section 3.4 presents the novel firm-based modeling framework proposed as part of this study. The modeling framework builds on the research team's knowledge base, the existing literature from freight modeling as well as logistic and management sciences, and the new understanding of stakeholder behavior gained from the face-to-face interviews. Section **Error! Reference source not found.** discusses the issues of scope and scale pertaining to the applicability of the proposed modeling framework.

### 3.1 Logistics Management Framework

Our proposed framework focuses on addressing one particular limitation of the existing supply-chain based freight demand models: each business establishment – defined as a single physical location where a business performs economic activities – is treated as a separate and independent decision-making agent. Inter-establishment interactions are considered in these existing models only between agents assuming different roles in the supply chain (e.g., between supplier and customer, between shipper and freight forwarder). In reality, however, when multiple establishments are under the common ownership of a firm, they interact with each other in the making of logistics and other business decisions. Such firm, hereafter referred to as multi-establishment firm, may benefit from individual establishments' proximity to suppliers and customers, flexibility in procurement and production, and specialization in activities (Maritan et al., 2004). To realize these advantages associated with the multi-establishment structure and achieve maximum profit for the entire firm, firms have to coordinate activities across establishments rather than manage each establishment independently (Bhatnagar et al., 1993). This interdependency means that the logistics management practices of establishments within multi-establishment firms may differ significantly from those of single-establishment firms. The implication of overlooking such intra-firm interaction in a freight demand model is nontrivial.

As shown in Table 3-1, at the national level multi-establishment firms are very prevalent and establishment-to-firm ratio increases as firm size increases. While most of small firms (1-19 employees) tend to consist of a single establishment (as reflected by the average ratio of 1.01), large firms of 500+ employees have, on average, 63.28 establishments per firm. Even though nationwide there are a lot more of the small firms (89.4%) than large firms (0.3%), these large firms account for more than 60% of the total sales receipts<sup>1</sup> and therefore have great influence on the nation's economy. The prevalence and economic impact of multi-establishment firms are also found in the specific manufacturing and wholesale trade industries, which are two major freight-generating industries. Thus, failure to represent multi-establishment firms' behavior in freight demand models is likely to have significant impact on forecasting accuracy.

Table 3-1. Number of Firms and Establishments by Employment Size and Industry in U. S.  
(SUSB, 2007)

	Employment Size of Firm			
	1-19	20-99	100-499	500+
<i>All Industries</i>				
Number of Firms	5,410,367	532,391	88,586	18,311
Number of Establishments	5,466,985	723,385	355,853	1,158,795
Average Establishment-to-Firm Ratio	1.01	1.36	4.02	63.28
Total Sales Receipts <sup>1</sup> (\$1,000)	3,975,109	3,792,921	3,612,050	18,366,661
<i>Manufacturing Industry</i>				
Number of Firms	213,074	55,603	13,945	4,079
Number of Establishments	213,509	59,596	23,030	35,220
Average Establishment-to-Firm Ratio	1.00	1.07	1.65	8.63
Total Sales Receipts <sup>1</sup> (\$1,000)	197,171	440,740	634,738	4,019,587
<i>Wholesale Trade Industry</i>				
Number of Firms	286,873	36,783	7,907	3,113
Number of Establishments	292,554	53,305	28,337	60,268
Average Establishment-to-Firm Ratio	1.02	1.45	3.58	19.36
Total Sales Receipts <sup>1</sup> (\$1,000)	872,353	899,444	771,807	3,442,613

In view of the inappropriate treatment of multi-establishment firms in previous freight demand models, this study sets out to consider a firm-based modeling approach that incorporates supply chain concepts and accounts for interdependency of establishments within a firm.

While business logistics management involves making a variety of decisions that fall within different planning areas (Ballou and Srivastava, 2007), this study considers the areas most relevant to freight transportation, including customer demand and service, firm structure and facility location, purchasing, inventory and ordering, and transportation. Figure 3-1 shows the set of key business decisions and the common principles based on which these decisions are made within each of these planning areas. Each business decision is labeled with its typical planning horizon. Strategic decisions are considered long-term with a planning horizon longer than one year; tactical decisions are made at an intermediate time interval (e.g., monthly); and operational decisions are related to daily or hourly logistics tasks.

The innermost circle in Figure 3-1 is *customer demand & service*, which is at the heart of a firm's operation and drives almost every aspects of logistics management. It is one of the most important factors for a firm to gain a leading position in today's competitive business environment. The three logistics areas (*firm structure and facility location, purchasing, and inventory and ordering*) depicted in the middle layer of Figure 3-1 are directly driven by customer demand and often influence each other in an intricate way. The outermost layer of Figure 3-1 refers to the *transportation* aspect of logistics management. The internal and

<sup>1</sup> Sales receipts are defined as the revenue for goods produced, distributed, or services provided.

external, inbound and outbound transportation decisions of a firm are directly driven by the many decisions listed in the middle layer of the diagram.

Each of the aforementioned five logistics areas are further discussed below.

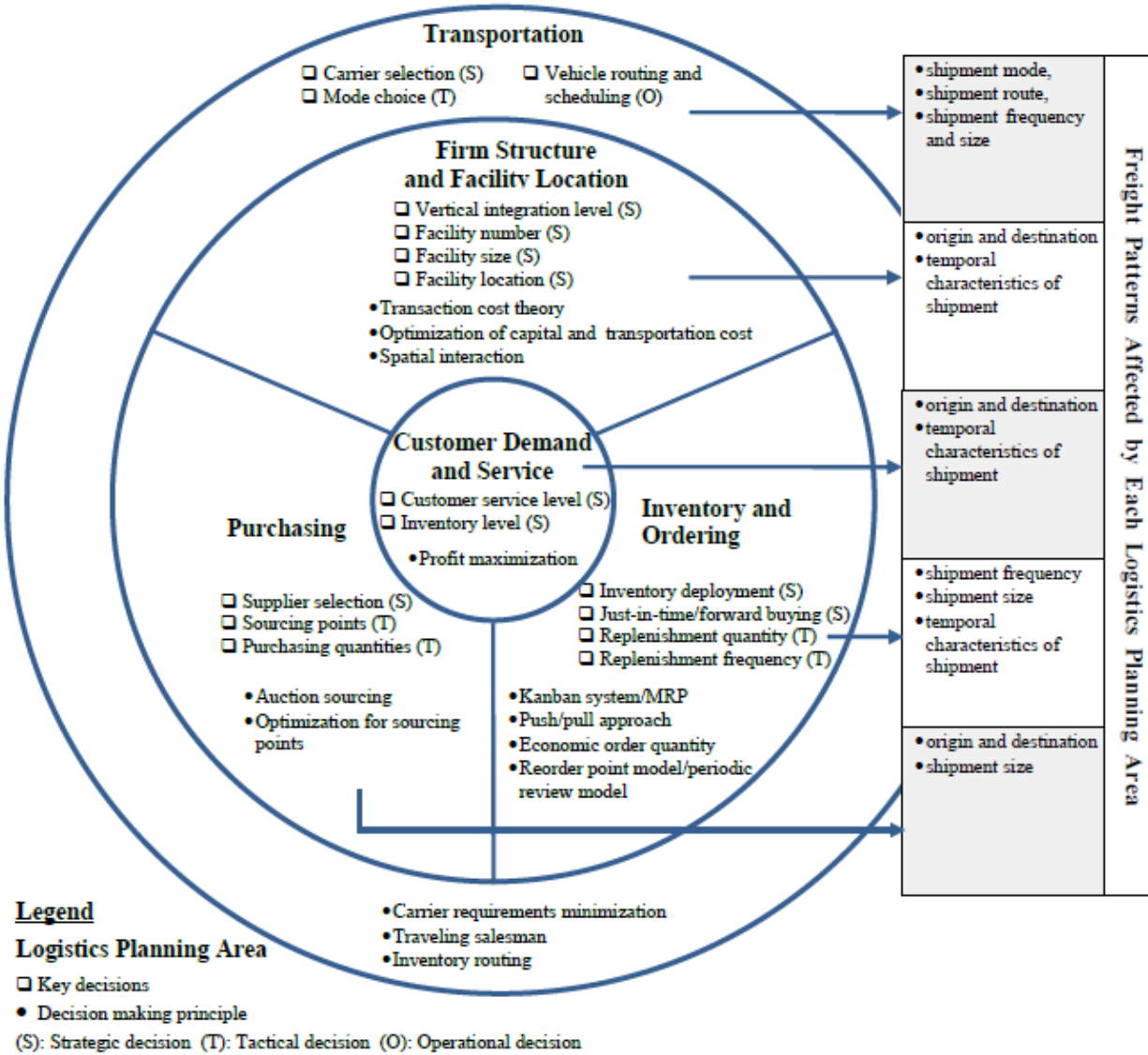


Figure 3-1. Overview of the business logistics management process

### 3.1.1 Customer demand and service

The spatial and temporal patterns of customer demand form the underlying constraints for a firm to manage purchases, schedule productions, locate inventories and arrange shipments. Typically, it is impractical and unnecessary for a business to equally satisfy all its customers' demand. The logistics area of customer service management entails setting the inventory levels for various items and the service levels (or fill rates) for customers. Here, service level is defined as the percentage of customer demand to be satisfied by on-hand inventory (Heskett, 1994).

Definitive evidences in practice have shown that the amount of sales increases with enhanced logistics customer service (Bartiz and Zissman, 1983). Meanwhile, a high service level typically requires decentralized inventory and frequent shipments with small quantities that result in added cost. Therefore, a business needs to strike a balance between increased sales and increased costs. The decision making behind customer service level and inventory level usually follows the profit maximizing principle. As such, different commodities and customers are assigned with different inventory and service levels (Kopczak and Johnson, 2003).

### 3.1.2 Firm structure and facility location

Firm structure is defined by a set of different but interrelated decisions, including vertical integration level, number and size of constituting facilities. Vertical integration level characterizes a firm's business boundary by determining whether engage in or outsource certain operation. For example, a manufacturer could integrate internal sales force to sell products rather than use independent marketing representatives. In contrast with so-called forward integration, the backward integration extends firm operation to its upper level of supply chain, i.e., in-house making some components or material required for its current production. The integration level is typically determined as a result of make-or-buy decision based on transaction cost theory, which is first introduced by Coase (1937) and used as a standard framework in business boundary study. Under this framework, not only the production technology determines the business boundary, the tradeoff between the relative transaction costs of external and internal commodity exchange plays key roles as well. Based on this theory, various studies have been performed to investigate the importance of other factors to make-or-buy decision making, such as asset specificity, uncertainty in volume and technology, etc. (Walker and Weber, 1984).

Based on the business boundary, a firm determines the number and size of its constituting facilities, and they are often considered jointly with the facility location decisions. These decisions establish the spatial patterns of commodity flows. They also affect the temporal patterns of logistics management since they determine the lead time needed to fulfill any inventory replenishment or purchase order. Extensive works in the field of operations research have been conducted to assist businesses in making these decisions in an optimal manner (Owen and Daskin, 1998) and they provide the premise for freight demand modeling. For example, there is usually one major driving force that dominates facility location choice (Ballou and Srivastava, 2007), such as the cost factor driving manufacturing plant and warehouse locations and potential revenues driving retail locations. The optimum facility location is determined by optimizing on the dominating factor while satisfying any associated constraints such as funds availability and demands to serve.

### 3.1.3 Purchasing

Purchasing refers to buying commodities from sources outside a firm; typical questions involved in purchase management are: where and from whom to purchase, and how much to purchase (Leeders et al., 2001). But as discussed in previous section, before making these decisions, a vertically integrated firm has the option to satisfy its commodity needs through in-house production. After internal sourcing for commodities, a firm relies on the outside suppliers in market for goods to meet its remaining demands. The problem of supplier selection has been studied extensively in operations research (Ho et al., 2010; Aissaoui et al., 2007). It is commonly recognized that, in addition to purchase costs, the quality of goods, services provided by supplier, and flexibility in satisfying customer needs play key roles in determining the competitiveness of suppliers. The actual selection of a supplier could take place through the auction sourcing process, in which suppliers are invited to auction on supplying for a customer and customer choose the one that win the auction. Another key observation regarding purchasing behavior is that firms increasingly look for long-term buyer-supplier relationship rather than focus on the cost minimization in one-time transaction.

### 3.1.4 Inventory and ordering

Inventory and ordering decisions are concerned with the transportation and storage of commodities throughout a firm's logistics channel, ranging from the stockpiles of extra raw materials purchased to the allocation of finished products at warehouses. For freight transportation, the key decisions are the quantity and schedule of inventory replenishment from inside firm resources and those decisions about commodity ordering from outside suppliers.

For the internal inventory replenishment, the push approach and pull approach serve as the basic management philosophies in determining replenishment quantity and frequency. The push approach allocates commodities to demanding points according to the forecasted demand at each location but sets inventory levels collectively if there are multiple locations to serve (Ballou and Srivastava, 2007). In addition to commodity needs at each location, the replenishment quantity is also determined based on production plant size, purchase quantity, and transportation quantity to achieve cost savings for the entire system. The push approach is therefore a reasonable approach when production and/or purchasing factors dominant inventory planning.

In contrast, the pull approach considers primarily only the local demand and cost conditions in determining replenishment quantity and frequency for each individual stocking point, and it is particularly popular for businesses operating at the lower end of a supply chain (e.g., retailers) (Andel, 1996). Most of the replenishment systems under pull approach are derived from the popular economic order quantity (EOQ) theory (Harris, 1913), in which the optimal order quantity is determined to minimize ordering cost and inventory carrying cost. Based on the EOQ theory, two fundamental pull inventory replenishment methods are developed: reorder point model and periodic review model (Stevenson, 2008). The reorder point model places an economic order quantity when inventory depletes to a critical point, which is set based on replenishment lead time and demands during lead time to assure customer demand could be satisfied before the next order arrives. The implementation of this model requires monitoring the inventory levels of each item and therefore incurs extra administration cost. The periodical review model audits inventory level at a fixed interval that is determined as the ratio between optimum order quantity and annual demand. At the end of each interval, an order is

placed to fill the inventory up to a predetermined maximum quantity. This model is preferred when multiple items are jointly ordered from the same vendor or when significant transportation savings could be achieved (Gill et al., 1985).

For the external sourcing, the ordering decisions are determined according to the buyer's production schedule or commodity demands, and two types of strategy dominate the ordering systems: forward buying and just-in-time. The forward buying is motivated by various price incentives offered by suppliers and/or by higher price expected in the future. Under such strategy, a firm may order commodities in large quantities that exceed its current requirements and create extra inventories. Therefore a firm operating forward buying strategy has to balance the additional inventory and the price advantages. On the other hand, the increasingly popular just-in-time strategy emphasizes on the scheduling of purchase to minimize inventory. It is an operating philosophy characterized by close relationships between buyers and suppliers through shared information, and minimal inventory as a result of frequent goods purchase and small-quantity transport. Typical ordering systems under just-in-time approach include KANBAN system using the reorder point method of inventory control that is applied under high demand uncertainty situation, and material replenishment planning (MRP) system for scheduling high-valued commodities or parts of reasonably known demand.

### 3.1.5 Transportation

The logistics decisions listed in the inner and middle layers of Figure 3-1 readily characterize a firm's freight transportation patterns in terms of origin and destination, shipment size, and schedule. Here, the transportation component of the logistics management process focuses on how goods are actually moved from one location to another using the multimodal transportation services and network. This includes decisions such as service provider, transportation mode, and vehicle/vessel routing and scheduling.

Outsourcing all or part of logistics function to a 3rd party logistics (3PL) service provider has become prevalent across the industry (Qureshi et al., 2007). A literature survey (Razzaque, 1998) indicates that the common driving forces for outsourcing logistics service include the globalization of business, just-in-time requirement and emerging technology and versatility of third parties. By outsourcing logistics service, a business expects to take advantages of strong cross-functional knowledge, logistics management expertise, efficiency improvement, etc. For a firm deciding to use 3PL service provider, it is necessary to select one or more appropriate carrier(s). According to Theodore and Goldsby (2000), carrier selection is often integrated with the selection of mode and carrier type in today's practice.

Either the shipper or the chosen carrier assumes the responsibility of choosing an appropriate mode to fulfill the shipments. It is commonly recognized that freight service quality, measured with reliability and flexibility in delivering freight, increasingly outweighs transportation cost factor in determining which mode to use (McGinnis, 1990; Evers et al., 1996). Freight service factor is often incorporated into mode appraisal through its indirect effects on inventory costs and sales. The optimum mode is then selected by balancing the trade-offs between transportation cost and service quality.

The task of routing and scheduling deals with arranging the order and path in which shipments are picked-up and delivered using the selected carrying equipment (trucks, vessels, or

flights). For modes other than trucks, the routing solution is typically driven by the need to minimize the number of carrying equipments to use. In contrast, highway freight routing is characterized by the desire to reduce total distance traveled and the number of empty trips. Unlike common route choice problems in passenger transportation planning, the freight vehicle routing problem takes into account the vehicle size and the loading condition as well since trucks pick up and deliver goods during the shipping process. Routing and scheduling are also constrained by the time window specified for delivery or shipment by each receiving and shipping facility. These characteristics translate the task into the typical transportation issue in operation research, ranging from the classical travelling salesman problem to the many variations of routing and scheduling (VRP) problem.

### **3.2 In-Depth Interviews with Stakeholders**

The interviews were conducted based on a list of talking points covering all five business areas outlined in Section 3.1. The interviewers were instructed to supplement the list with any follow-up questions as needed during the interview process. A total of 7 stakeholders were interviewed. These include business owners, chief operating managers, and purchasing/shipping managers from businesses in the Milwaukee, WI, and Houston, TX, area. The interviews ranged from 40-minutes to 2 hour long. While most of the conversations help validate the framework outlined in Section 3.1 and a draft modeling framework that the research team had sketched out at the time, there were a few surprises or practices that turned out more prominent than we expected. These are briefly highlighted below.

- Large firms are moving towards more vertical integration within the firm and, at the same time, have less collaboration with other external firms. Collaboration across firms is more prevalent and necessary among smaller firms.
- As part of the collaboration among manufacturers, manufacturer A could manufacture and ship a product to manufacturer B's customer in B's name without having A's name or address on any paperwork or anything shipped to the customer. This prevents the customer from accurately identifying (and reporting to any survey) the true origin of what they receive.
- The level of willingness varies greatly across interviewees to disclose information about their specific suppliers, carriers, and customers. It seems to be a matter of individual company policy and not necessary dependent on the industry sector or company size.
- The distinction and designation of purchasing versus transportation staff in larger companies but often not the smaller companies does not necessarily lead to more efficient operations. In fact, as revealed by a transportation department manager, transportation decisions are often an afterthought after the sourcing decisions have been made. Depending on how a company is structured, the level of interdependency across sourcing/inventory/transportation decisions can be very different. Simplifying assumptions will inevitably have to be made in order to develop operational freight models that represent "common" practice.
- The factors taken into the supplier choice consideration also differ a lot across companies. Some claimed to consider "quality" as the top criterion. Others said "cost" is the biggest influence factor.

- As expected, most interviewees agreed with the benefit and expressed the desire of having at least some control over how their suppliers ship the materials to them. One manufacturer pointed out that, in cases where the materials are rather sensitive, it is actually better to have a supplier taking full responsibility of the shipping because of the *possibility* of damage during transportation. Otherwise, if the supplier has no in the matter, the manufacturer would prefer to ship the materials with their own carriers to increase the volume in-house for future contract negotiations.
- Companies that produce a lot of customized products are more likely to order what they need as orders arrive (just in time). Transportation cost involved in sourcing is not as much of a concern since it is often absorbed by the customer.
- Manufacturers who sell internationally or to specific markets (such as VA hospitals) have more knowledge about the upstream of their supply chain. Because of compliance requirements, they need to know the country of origin of every raw material used in their production. That is, they would know who the supplier of their supplier is, but not necessarily the transportation arrangements along the way.
- Purchase and inventory decisions depend not only on past data, but also future trends (i.e. what is “in” for the next season).
- Depending on the range of their products, it is quite typical of a company to use a mix of parcel, LTL, trailer load, and broker services. This points to added challenge for micro-level models to capture the decision-making at this level of detail.
- At an extra cost, shippers can have added control over their shipping service with a carrier (eg FedEx).
- The practices of lean manufacturing and just-in-time production have led to increased use of carrier services because carriers could guarantee transit time.

### **3.3 Intra-Firm Interdependency and Implication on Freight Transportation Patterns**

The logistics management considerations and approaches differ between single- and multi-establishment firms in many ways because a multi-establishment firm needs to make well-coordinated logistics decisions in order to attain the benefits of having multiple facilities at differing locations. These differences, together with their potential implications on freight transportation patterns, are discussed below.

#### **3.3.1 Firm structure and facility location**

With regard to firm structure and facility location, multi-establishment firms definitely face a more complex problem than single-establishment firms. This is because the multiple facilities involved in a multi-establishment firm cannot be considered as economically independent and their locations are driven by different forces depending on the type of facility (Ballou and Srivastava, 2007). For example, in the wholesale/retail industry, consumer demand



is the key determinant driving the location of retail outlets. The location decision is also affected by the effects of cannibalization and market expansion (Berman and Krass, 2002). Cannibalization refers to the situation where new facilities attract some of the demand from existing facilities and may result in diminished profits for the entire firm. However, this effect could be partially or fully offset by market expansion, which refers to the case that new facilities trigger new consumer demands and therefore make the market even bigger.

In the manufacturing industry, facility location decisions of a firm depend largely on its vertical integration level, which is reflected as the production scheme adopted. As classified by Schmenner (1979), typical production schemes include:

- *product plant strategy*, in which distinct products or product lines are manufactured in each plant of a firm to serve the entire domestic market area.
- *market area plant strategy*, in which all or most of the product lines are manufactured in each plant of a firm to serve a regional market.
- *process plant strategy*, in which the output products of a plant serve as input materials or components for other plants within the same firm.
- *general purpose plant strategy*, which refers to a combination of any two or three of the above listed strategies.

The production schemes act as guidelines for a multi-establishment manufacturer to locate multiple plants. For example, a manufacturer with the market area plant strategy tends to have spatially scattered plants. On the other hand, a manufacturer operating under the process plant strategy are likely to locate its facilities closely to reduce lead time and transportation cost.

### 3.3.2 Purchasing

With regard to purchasing, multi-establishment firms have the opportunity to gain economies of scale in purchase by sourcing large quantity for its establishments from a common supplier (Oboulhas et al., 2005). This so-called centralized purchasing strategy is found in many large firms such as Whirlpool, General Motors, Dells, Wal-Mart and IBM (Wisner et al., 2005; Benton, 2007). The successful implementation of this strategy relies on a variety of factors such as the commonality of material supply, long-term availability, and specialized purchasing skills and knowledge (Corey, 1978). Although centralized purchasing presents certain advantages, a firm operating under this strategy may sacrifice flexibility of sourcing and suffer from longer lead time in its local establishments. In order to benefit from both the centralization and decentralization, a compromised approach is called ‘centralized pricing with decentralized purchasing’, in which suppliers are selected through firm-to-firm negotiation at centralized level and each establishment makes its own orders by specifying order quantity and shipment frequency.

To illustrate the impact of centralized purchasing strategy on freight movement, Figure 3-2(a) shows two scenarios both involving two manufacturing plants and two suppliers that supply the same material. In scenario A, the two plants correspond to two independent firms  $i$  and  $j$ ; whereas in scenario B both plants belong to the same firm  $i$ . Assume that the two supplier

firms,  $a$  and  $b$ , are virtually identical except in their locations. In scenario A, if the purchase costs offered by both suppliers are the same and transportation costs are proportional to the physical distances, then both manufacturing firms would independently choose the supplier closest to the firm. That is, firm  $i$  would use supplier  $a$  and firm  $j$  would use supplier  $b$ . In scenario B, when the two plants are operated by the same firm that exercises centralized purchasing, their purchases would likely to be combined and sourced from the same supplier, say  $a$ , for the benefit of a discounted purchase price. In this case, the resulting O-D flow pattern, shipment size, delivery route and timing may all differ from that of scenario A.

### 3.3.3 Inventory and ordering

Single-location firms are usually too small to separate the inventory control problem from production scheduling. In comparison, multi-establishment firms that comprise multiple echelons (e.g. warehouse-plant for a manufacturing firm or warehouse-retail outlets for a wholesaler) have a more complex inventory behavior. One of their priority issues is the selection of warehouses to replenish their individual manufacturing plants or retail outlets. This decision could be made at a strategic level as a warehouse location choice problem or at a more tactical level as an allocation problem.

Figure 3-2(b) illustrates a possible difference in inventory replenishment behavior between a single-establishment firm and a multi-establishment firm. In scenario A where three single-establishment firms  $a$ ,  $b$ , and  $c$  all order materials from the same supplier  $i$ , it is up to each individual firm to determine its order quantity and schedule, thus representing a pull approach. In scenario B, if now the three receiving plants are all owned by the same firm  $i$  that also operates the warehouse stocked with the needed materials, the firm has the ability to coordinate replenishment schedules and the opportunity to combine replenishment quantities across the three receiving plants. This allows for a push approach that could lead to different ordering pattern as compared to the more frequent shipments with smaller quantities in scenario A.

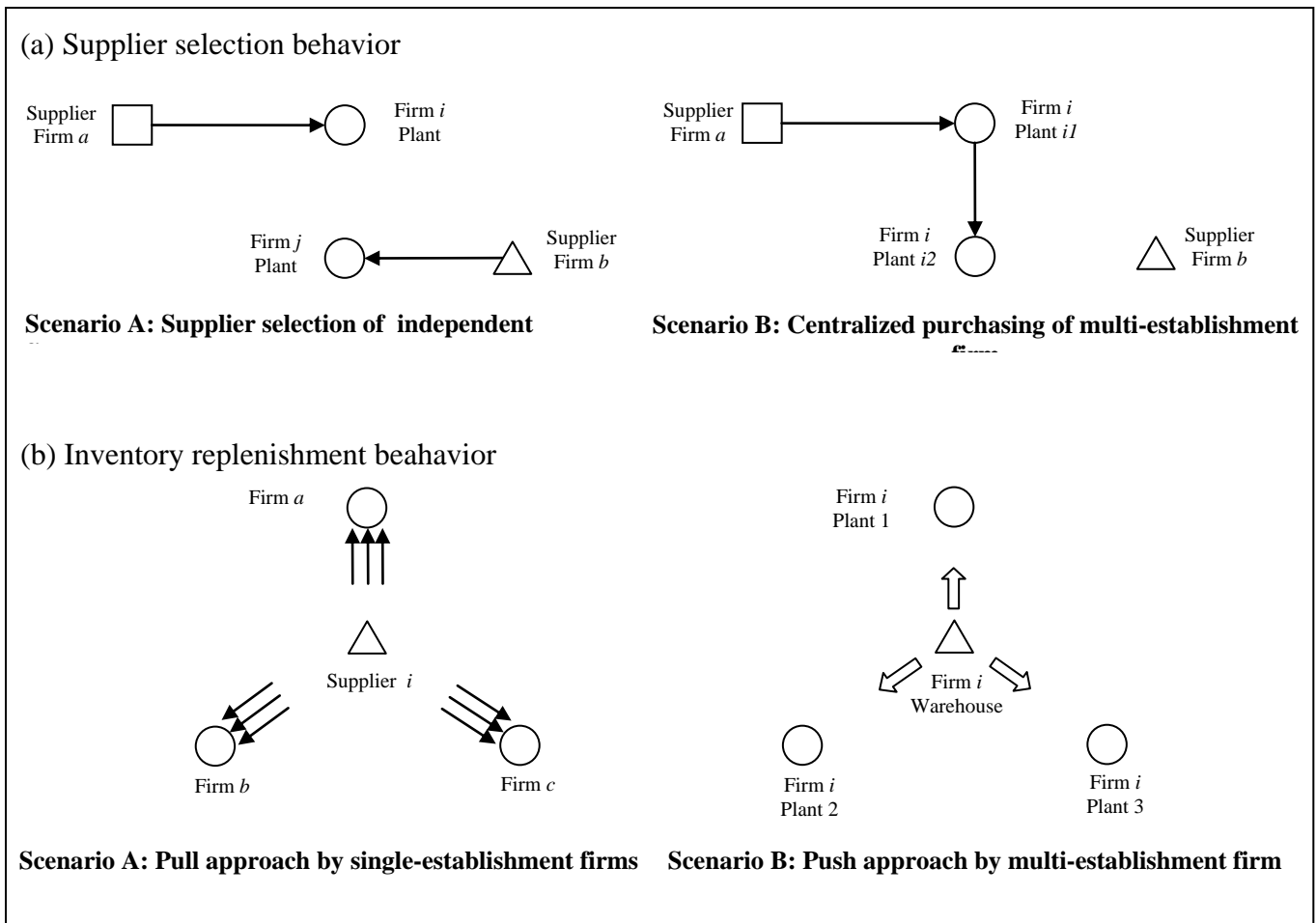


Figure 3-2. Differences between single- and multi-establishment firms

Another inventory and ordering paradigm is the vendor-managed inventory (VMI) approach, in which the supplier assumes responsibility to reviewing customer's inventory levels, usually on a daily basis, and controls the timing and quantity of customer resupply decisions rather than fills orders as they are placed (Cetinkaya and Lee, 2000). Because of an increasing emphasis on coordination and collaboration in supply chain management, suppliers and customers are often considered a system in designing optimal order arrangement under a multi-items and multi-establishments context (Khouja and Goyal, 2008). The order quantity and schedule are determined to minimize the ordering cost and inventory holding cost for entire system.

### 3.3.4 Transportation

The presence of multiple establishments within a firm adds complexity to the transportation problem in that there may be multiple origins serving multiple destinations. It leads to the opportunity for vehicle consolidation, through which less-than-truckload shipments from multiple origins could be placed on the same vehicle through well-coordinated routing and scheduling. The combined shipment size may also make a mode such as rail more attractive. It

should be noted, however, that similar opportunities of consolidation are also practiced by third party logistics providers in dealing with both single- and multi-establishment firms.

As discussed above, multi-establishment firms may operate in a significantly different way as compared with single-location firms due to the resources possessed and constraints brought by the multi-establishment structure. The resulting freight transportation also presents different patterns in almost every aspect including origin and destination, shipment size and frequency, schedule, mode used, and routing. Failure to account for the multi-establishment structure tends to produce incorrect freight patterns modeled.

### **3.4 FIRM-BASED MODELING FRAMEWORK**

Based on the logistics management concepts discussed in section 3, a firm-based framework for modeling freight demand is presented in this section. This proposed modeling framework is unique in that (a) its underlying decision making units are firms, as opposed to establishment, and (b) it captures explicitly many of the behavioral differences between single- and multi-establishment firms.

Figure 3-3 presents the overall structure and application procedure of the modeling framework, with the right hand side being its major modules, which consists firm creation, purchasing, inventory and ordering, and transportation. Depicted on the left hand side of Figure 3-3 is how the various modeling components would be applied in a micro-simulation environment to simulate the logistics decisions and freight movements associated with all firms in a study region. Specifically, the simulation procedure would be a hybrid of longitudinal and latitudinal simulation approaches. First, firm synthesis is performed to generate a collection of firms located within the study region. Similarly, establishment synthesis is performed to generate individual establishments. Then the firm structure and facility location module is utilized to match establishments to firms and determine additional attributes for each firm. Next, firms' annual demands and supplies are simulated one at a time. If a firm has multiple establishments, its internal sourcing/supplying decisions are also simulated and the demand and supply quantities are updated. External sourcing is then simulated in the next iteration across all firms. This involves simulating the establishments' choices of supplier, purchase quantity, and sourcing point. At this point, the annual amounts of commodities to be moved between all pairs of establishments are determined.

Next, the simulation process focuses on how annual commodity flows are spread out over the course of a year. This is accomplished by simulating the ordering quantity, frequency, combination structure, and timing for all commodities, one firm at a time. At the end of this step, each order, or shipment, is assigned with a known quantity and delivery date. The simulation then focuses on firms that assume the roles of suppliers and/or carriers who make transportation decisions at the operational level. At the end of this procedure, all shipments are assigned with modes, consolidation locations, vehicles, routes and delivery/arrival times.

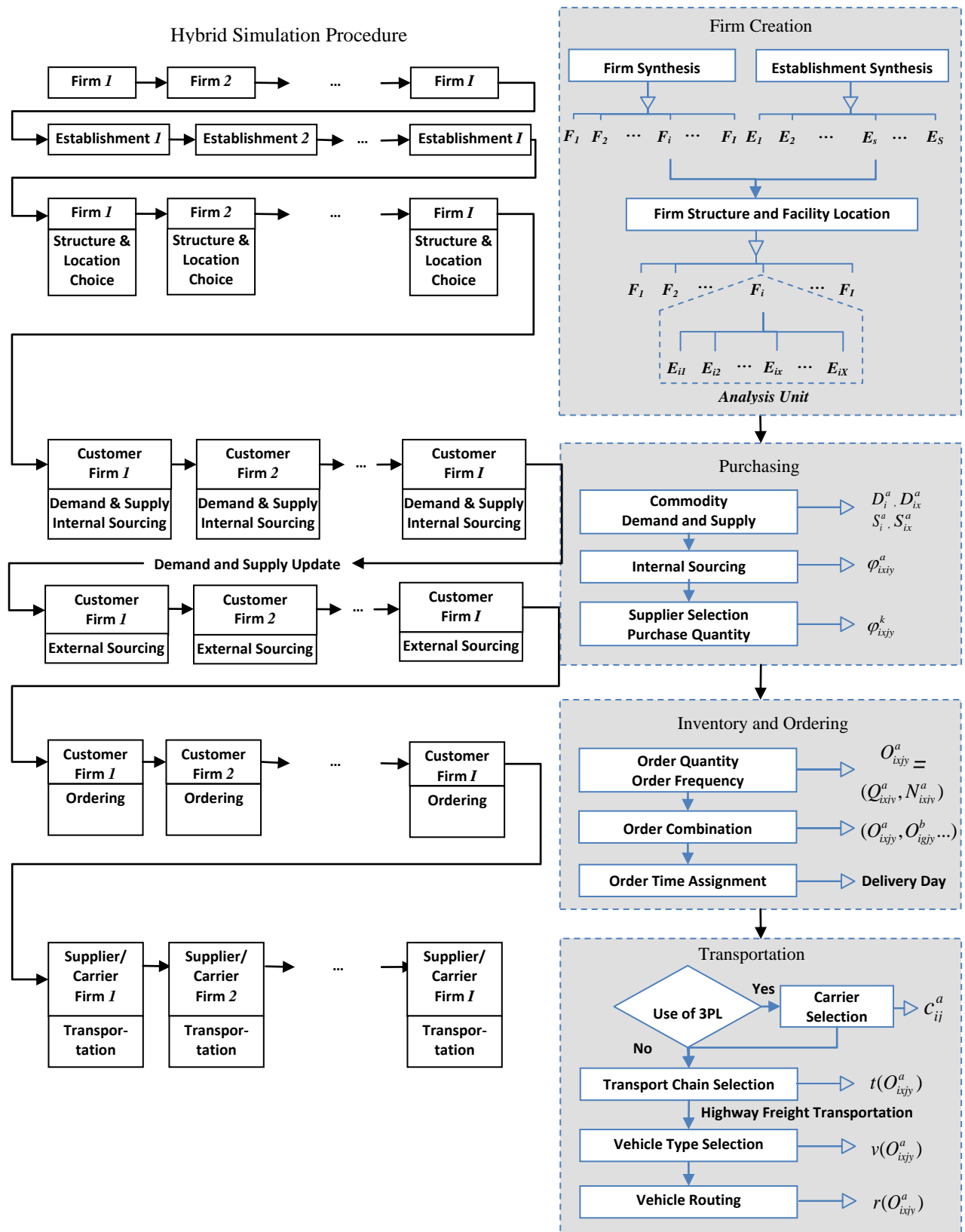


Figure 3-3. Firm-based freight demand modeling framework

The remaining of this section describes the methodologies proposed for developing the various components that constitute of this firm-based modeling system. It should be noted that not all model components in the system have been fully calibrated. The methodologies described below reflect what the authors consider as the most suitable and doable based on the data being collected and data readily available. The details in the mathematical structure and/or the exogenous variables to be incorporated in the models are subject to changes based on the quality and statistical power of the final data.

### 3.4.1 Firm Creation

The synthesis procedure used to create firms and establishments is similar to that used for synthesizing households and population for activity-based modeling (see, e.g., Guo et al., 2007). The major source of data is the 2007 economic census. At the end of the synthesis process, each firm  $i$  is defined by a vector of key attributes, denoted as  $F_i$ , that includes primary industry type and firm size. Similarly, each establishment  $s$  is defined by a vector  $E_s$  that includes attributes such as employment size, facility area, economic activity, and annual sales.

Another key attribute for a firm is its vertical integration level, which is not included in general economic census data and therefore requires being further estimated. As previously discussed, a firm's vertical integration level determines the additional business activities involved besides its primary operation. Theoretically, a firm could incorporate the production and distribution activities through entire supply chain into its in-house operation. Constrained by physical resources, technologies and expertise possessed by a firm, however, fully vertical integration is likely to diminish the operation efficiency. Therefore few firms adopt integration at such level, with some exceptions in industries of relatively simple supply chain structure, such as oil industry. Considering this fact and the potential errors introduced by tracing firms' vertical integration structure along entire supply chain, it's decided to focus on the industries with immediate and substantial links to the study firm's industry from both ends of a vertical supply chain. Following the definition used by Hortacsu and Syverson (2009), the substantiality of relationship between two industries is determined by the relative volume of commodity flows derived from industry input-output matrices.

After determining all immediate industries that have substantial trade volumes with the primary industry of the study firm, a discrete-continuous choice model is applied to jointly examine 1) whether going into a specific upstream/downstream industry; and 2) the number of establishments the firm has that operate the industry. It should be noted that though a firm may involve in many secondary industries besides its primary industry, each establishment is assumed to perform only one type of economic activity. This assumption is important in determining the type of goods produced/shipped by each establishment, especially given limited availability of data to calibrate the model. Based on random utility maximization (RUM), the utility  $U_i(c)$  that a firm  $i$  obtains from entering an immediate industry  $c$  and operating number of establishments in industry  $c$  are specified as:

$$U_i(c) = f(F_i, c, s(c)_i) + \varepsilon, \text{ and} \quad (\text{EQ 3-1})$$

$$s(c)_i = f(F_i, c) + \eta \quad (\text{EQ 3-2})$$

By performing the industry entering examinations for all immediate industries with substantial links, the secondary industry type  $c$  and number of establishments operating in the industry  $s(c)_i$  of a firm  $i$  are determined, and they are added as firm attributes. Then the discrete choice model is adopted to estimate the firm-establishment relationship, in which the utility  $U_i(x)$  that a firm  $i$  attains from choosing establishment  $x$  is specified as:

$$U_i(x) = f(F_i, E_x) + \varepsilon \quad (\text{EQ 3-3})$$

This model is repeatedly performed for each industry involved by the firm until the number of establishments in that industry determined in model (2) is satisfied. Hereafter if an establishment is associated with firm  $i$ , it is denoted as  $ix$ .

Next, locations of establishments and headquarters are determined using another discrete choice model. The utility attainable by establishment  $x$  of firm  $i$  from choosing location  $l$  is defined as:

$$U_{ix}(l) = f(F_i, E_{i1}, \dots, E_{ix}, A_l) \quad (\text{EQ 3-4})$$

where  $A_l$  describes location  $l$ 's characteristics, including land price, surrounding land use, local economic index, and transportation accessibility. As previously discussed, the presence of existing establishments within a firm has impacts on its location decision of new establishment, and such influence may exhibit in various ways under different production schemes. In order to account for the spatial interaction effect, the inter-establishment correlations could be incorporated into the utility function to represent the influence of other establishments' location choices on the location decision of establishment  $ix$  (see, e.g., Nguyen and Sano, 2010). Once a location is assigned to an establishment, the attributes in  $A_l$  are absorbed into  $E_{ix}$ .

### 3.4.2 Purchasing

The purchasing module determines annual goods flows between establishments. The annual demand of establishment  $x$  from firm  $i$  for commodity  $a$ , denoted as  $D_{ix}^a$ , is first determined based on a regression model:

$$D_{ix}^a = f(F_i, E_{ix}, P^a, P^{k(k \leftarrow a)}) \quad (\text{EQ 3-5})$$

where  $P^a$  is the generalized purchase price of commodity  $a$  and  $P^{k(k \leftarrow a)}$  is the generalized sell price of commodity  $k$  that uses commodity  $a$  as a primary material. And the industry input-output datasets are used again to identify the material needs of certain commodity production. The incorporation of output commodity sell price  $P^{k(k \leftarrow a)}$  allows us to take into account the business market effects on firm economic activities (e.g., material demand and production), thereby better approximating the forecasts of production needs and commodity demands according to general economic data. Similarly, the annual supply of commodity  $k$  by establishment  $x$  of firm  $i$ ,  $S_{ix}^k$ , is determined by:

$$S_{ix}^k = f(F_i, E_{ix}, P^k, P^{a(a \rightarrow k)}) \quad (\text{EQ 3-6})$$

Once commodity needs and products supply at each establishment are determined, the annual demands of commodity  $a$  and supply of commodity  $k$  at the firm level is calculated as the sum across all member establishments. That is:

$$D_i^a = \sum_x D_{ix}^a, S_i^k = \sum_x S_{ix}^k \quad (\text{EQ 3-7})$$

The next model, internal sourcing, is concerned with only multi-establishment firms. The premise of this model is that a firm would attempt to use resources available within firm before making purchases from another firm. As such, the problem of internal sourcing becomes a problem of distributing commodities from supply points to demand points within a firm. This is similar to the classical transportation problem (Hitchcock, 1941), whose objective is to minimize the total transportation cost incurred in distributing commodities and the constraints are that all supply leave their source points and all demand are satisfied. For the internal sourcing problem, however, the internal supply within a firm may or may not suffice to serve all in-house demands. Therefore, a variation of the standard transportation problem is proposed here to consider both possibilities. Let  $TC_{ixiy}^a$  be the transportation cost for moving a unit weight of commodity  $a$  from establishment  $y$  to establishment  $x$  within firm  $i$ . Let  $\varphi_{ixiy}^a$  be the commodity flow  $a$  from establishment  $y$  to establishment  $x$  within firm  $i$ , measured in weight. Then the internal sourcing problem is formulated as follows:

$$\begin{aligned} \text{Min } & \sum_{x=1}^X \sum_{y=1}^Y TC_{ixiy}^a \varphi_{ixiy}^a & (\text{EQ 3-8}) \\ \text{s.t. } & \sum_{x=1}^X \varphi_{ixiy}^a \leq S_{iy}^a, & \text{for } y = 1, 2, \dots, Y \\ & \sum_{y=1}^Y \varphi_{ixiy}^a = \min(D_{ix}^a, \sum_{y=1}^Y S_{iy}^a) & \text{for } x = 1, 2, \dots, X \\ & \varphi_{ixiy}^a \geq 0 \end{aligned}$$

The first constraint ensures that the outbound commodity at each location does not exceed its supply capacity; the second constraint specifies that the total inbound commodity at a demanding location either satisfy its demand or use up all internal supply. After internal sourcing, the quantities of supply and demand at each establishment are updated.

The remaining demands of establishments are satisfied from outside suppliers. Multi-establishment firms have the choice between using common suppliers for its multiple establishments or allocating supplier selection rights to its organizational units. Both the centralized purchasing and decentralized purchasing strategies have their own advantages; however, there is no clear cut-off criterion to distinguish which strategy is adopted by a firm. In addition, a hybrid purchasing strategy is becoming popular to allow both centralized decision making at firm level for some establishments and individual supplier selection for remaining establishments. Hence, instead of explicitly modeling centralization/decentralization strategy of a firm, the framework considers the supplier selection at establishment level. And to capture the



centralized purchasing behavior, the model incorporates the interaction between establishments within a firm in supplier selection, as that described in establishment location choice with alternatives changed from locations to suppliers. The supplier selection decision is jointly modeled with purchase quantity decision using a discrete-continuous structure:

$$U_{ix}^a(jy) = f(F_i, E_{i1}, \dots, E_{ix}, \phi_{ixjy}^a) + \varepsilon, \text{ and} \quad (\text{EQ 3-9})$$

$$\phi_{ixjy}^a = f(D_{ix}^a, E_{ix}, F_j, E_{jy}, S_{jy}^a) + \eta \quad (\text{EQ 3-10})$$

EQ 3-11 gives the utility associated with establishment  $x$  in firm  $i$  choosing establishment  $y$  in firm  $j$  to supply commodity  $a$ ; EQ3-12 represents the annual purchase quantity. Potentially, the error term  $\varepsilon$  in EQ 3-13 could be further expanded to incorporate autoregressive term measuring the similarity of supplier establishments. Following the idea of McMillen (1992), who applied the spatial autoregressive term to account for spatial correlations of alternatives in modeling housing choice behavior, here the “distance” in autoregressive term could be defined as a dummy variable to indicate whether supplier establishments belong to one single firm. By incorporating such ownership correlation among supplier establishment alternatives, the centralized purchasing behavior at firm-to-firm level could be better represented, though the supplier selection is modeled at establishment level.

It should be noted that the establishment demands may not be automatically satisfied after this external sourcing, as an establishment may purchase from multiple suppliers. If the commodity needs does not meet by the primary supplier establishment, the supplier selection and purchase quantity model is repeated to estimate the secondary supplier until the commodity needs is fully satisfied.

### 3.4.3 Inventory and Ordering

In this module, the annual commodity flows are divided into a series of individual orders throughout a year. The consumption of goods in establishments is assumed to be steady and continuous, therefore the demands of goods exhibit a constant pattern from order to order and a uniform order quantity applies. It is recognized that some products are highly seasonal (e.g., fashion apparel), however, it requires detailed commercial trading data to capture seasonal variation and this is out of the scope of this study.

For commodities with approximately constant demand, the economic order quantity (EOQ) theory establishes the basis for determining optimal order quantity  $Q_{ixjy}^k$ . The theory views the total logistics cost  $TOC_{ixjy}^a$ , which consists of ordering cost and inventory carrying cost in basic form, as a function of order quantity:

$$TOC_{ixjy}^a = \frac{\phi_{ixjy}^a}{Q_{ixjy}^a} CO_{ixjy}^a + \frac{I_{ix}^a C_{ixjy}^a Q_{ixjy}^a}{2} \quad (\text{EQ 3-141})$$

where  $CO_{ixjy}^a$  is the ordering cost measured in dollars per order,  $I_{ix}^a$  is the inventory carrying cost as a percent of item value measured as percent/year, and  $C_{ixjy}^a$  is the item value carried in inventory measured in dollar per ton. Based on the first order condition, the optimal order quantity that minimizes the total logistics cost is given by:

$$Q_{ixjy}^a = \sqrt{\frac{2\phi_{ixjy}^a CO_{ixjy}^a}{I_{ix}^a C_{ixjy}^a}} \quad (\text{EQ 3-15})$$

If constant demand (i.e. regular order intervals) is assumed, then annual order frequency is computed as the ratio between the annual purchase quantity and the optimal order quantity:

$$N_{ixjy}^a = \phi_{ixjy}^a / Q_{ixjy}^a \quad (\text{EQ 3-16})$$

The order quantity  $Q_{ixjy}^a$  and frequency  $N_{ixjy}^a$  together define a set of orders of commodity  $a$  made by establishment  $x$  in firm  $i$  from establishment  $y$  in firm  $j$  throughout a year. For the ease of subsequent discussion, each set of orders is denoted by  $O_{ixiy}^a = (Q_{ixiy}^a, N_{ixiy}^a)$ .

In order to incorporate the effects of joint ordering, an order combination model is proposed in which orders are combined from a customer firm's perspective. The model takes a binary choice structure, where the utility obtained by combining two orders  $O_{ixjy}^a$  and  $O_{igjy}^b$  of commodities  $a$  and  $b$  to destinations  $ix$  and  $ig$ , respectively, is specified as follows:

$$U_{(O_{ixjy}^a, O_{igjy}^b)}(\text{combine}) = f(a, b, E_{ix}, E_{ig}, E_{jy}, N_{ixjy}^a, N_{igjy}^b, Q_{ixjy}^a, O_{igjy}^b) + \varepsilon \quad (\text{EQ 3-174})$$

Based on the probability given by the binary choice model, each order within the order pools of a customer firm is considered to be combined with another order by Monte Carlo simulation. This process results in a set of combined orders such as  $(O_{ixjy}^a, O_{igjy}^b \dots)$ .

The order time assignment model determines whether an order – single or combined – is to be shipped to its customer on any given day. Because shipments are assumed to be sent on fixed intervals, the probability to ship an single order  $O_{ixjy}^a$  is given by  $\frac{N_{ixjy}^a}{365}$ . For a combined order, the probability to be shipped on the day is the average of the probabilities for each separate order. For example, if a combined order consists of two orders, the probability that the combined shipment takes place on the day is given by  $\frac{1}{2} \frac{N_{ixjy}^a}{365} + \frac{1}{2} \frac{N_{igjy}^b}{365}$ .

Potentially, the shipping probability for a combined order could be further weighted by the value of the commodities in each order, implying that orders of higher value dominates the shipping date arrangement in a combined order.

### 3.4.4 Transportation

Once the spatial and temporal flows of shipments are determined between firms and establishments for a given day, the Transportation module translates these shipment flows into traffic flows on the multi-modal network.

First, the supplying firms choose between outsourcing the shipments to 3PL service providers and using in-house fleet. This is determined by a binary choice model. The utility  $U_{ij}^a(LSP)$  that a supplying firm  $j$  obtains from using a logistics service provider (LSP) to ship commodity  $a$  to its customer firm  $i$  is specified as:

$$U_{ij}^a(LSP) = f(F_j, F_i, \varphi_{ij}^a) + \varepsilon \quad (\text{EQ 3-185})$$

If a firm decides to outsource shipments, the next step is to choose a carrier. The choice problem is modeled as a discrete choice problem with the utility associated with carrier  $c$  specified as:

$$U_{ij}^a(c) = f(F_j, F_i, F_c, \varphi_{ij}^a) \quad (\text{EQ 3-196})$$

Next, a transport chain model similar to that proposed by de Jong and Ben-Akiva (2007) is used to determine the transport mode(s) and transshipment location(s) (if any) involved in fulfilling each shipment. A transport chain  $t$  is defined as a series of legs  $1, 2, \dots, n, \dots, N$ , and each leg of the chain is characterized by a transshipment location  $h$  (e.g., a rail station) and the mode used  $m$  to transport the shipment there:

$$t = \{(h_1^t, m_1^t), (h_2^t, m_2^t), \dots, (h_n^t, m_n^t), \dots, (h_N^t, m_N^t)\} \quad (\text{EQ 3-207})$$

Under this setting, the transshipment location and mode of last leg are the actual customer destination of a shipment and transport mode used when it arrives at the customer, respectively. The utility attainable by choosing a specific transport chain is proposed as the sum of the utility associated with each leg of the chain:

$$U_{ixjy}^a(t) = \sum_{n=1}^N U_{ixjy}^a(n) + \varepsilon \quad (\text{EQ 3-218})$$

The utility associated with using a leg  $n$  is the same as that of choosing mode  $m_n^t$  and transshipment location  $h_n^t$  on leg  $n$  and is specified as:

$$U_{ixjy}^a(n) = U_{ixjy}^a(h_n, m_n) = f(F_i, F_j, E_x, E_y, Q_{ixjy}^a, A_{h,n}, rate_{m,n}, time_{m,n}) \quad (\text{EQ 3-229})$$

where  $A_{h,n}$  indicates the attributes of transshipment location  $h$  on leg  $n$ ;  $rate_{m,n}$  and  $time_{m,n}$  denote the freight transportation cost and travel time of using mode  $m$  on leg  $n$ , respectively. These utility specification are then incorporated in a discrete choice model to determine all the modes and transshipment locations involved in a shipment.

The last part of the transportation module involves scheduling and routing individual shipments onto their respective modal equipment and network while satisfying various constraints such as equipment capacities, link capacities, and delivery time windows. The process should also be sensitive to policy and planning variables such as pricing, size and weight permitting, safety and travel time reliability. These criteria render the shipment arrangement a major methodological challenge on its own, especially for highway freight transportation in which shipment equipment varies a lot. The development of this model component is therefore outside of the scope of the current paper and requires drawing from the state-of-the-art algorithms from fields such as dynamic traffic assignment and operations research.

### **3.5 Limitations**

Obviously, no freight modeling system could fully capture every aspect of freight stakeholder behavior. The proposed work is no exception. During the design of the proposed modeling framework, certain simplifications and assumptions have been incorporated to assure its operational ability, resulting in the following limitations:

- It is known that, in practice, single-establishment firms sharing similar roles in a same supply chain could establish alliance and form a purchasing group to gain bargaining power and obtain economies of scale through joint ordering. However, such a horizontal alliance between firms is not represented in the proposed framework, but could be considered as expanding the concept of joint decision-making from the intra-firm context to inter-firm context.
- Price policy is not explicitly modeled in the proposed framework. As indicated in this paper, the purchasing decisions depend on the price policies of suppliers. Such price policy varies from firm to firm and is difficult to observe. As a result, the proposed framework uses firm and establishment attributes as proximity variables to represent the effects of different price policies.
- A constant demand pattern is assumed for the modeling of ordering behavior. However, some commodities exhibit rather seasonal demand patterns and irregular order quantities and intervals. While it is highly desirable to capture such seasonal variation accurately, this would require a data program that monitors the fluctuation in market fluctuation and commodity flow across different times of a year and preferably for multiple years.

## **CHAPTER 4. NORTHEAST REGIONAL TRAVEL DEMAND MODEL**

This chapter documents the work performed for Task 4, which entails assessing the freight transportation component of version 11 of the Wisconsin Northeast (NE) Region Model. The chapter documents the research team's understanding of the NE model structure, discusses the model's strengths and limitations, and concludes with the research team's recommendations on ways to further improve the model.

### **4.1 NE Model Overview**

The Northeast Regional Travel Demand Model (hereafter referred to as the NE Model) was developed to provide a decision-making tool for the Wisconsin Department of Transportation's (WisDOT) Northeast Region. The development of the NE Model is a collaborative effort with WisDOT, Brown County Planning, East Central and Bay-Lake Regional Planning Commissions. The model builds on the existing Fox Valley model and covers counties of Brown, Calumet, Dodge, Door, Fond du Lac, Kewaunee, Manitowoc, Oconto, Outagamie, Shawano, Sheboygan, Washington, Waupaca, and Winnebago, as shown in Figure 4-1. The NE model includes the five metropolitan planning areas of Green Bay, the Fox Cities (Appleton-Neenah), Oshkosh, Fond du Lac and Sheboygan. It includes the entire US 41 corridor and most of northeast Wisconsin. The model covers 2585 internal traffic analysis zones (TAZ) indexed from 1 to 2774 and 64 external zones indexed from 2801 to 2864. The model includes a conventional four-step model component for passenger travel and a 3-step truck model component for freight transportation. The model has been calibrated for base year 2005 and forecasts daily auto and truck traffic for the future years (2020, 2035).

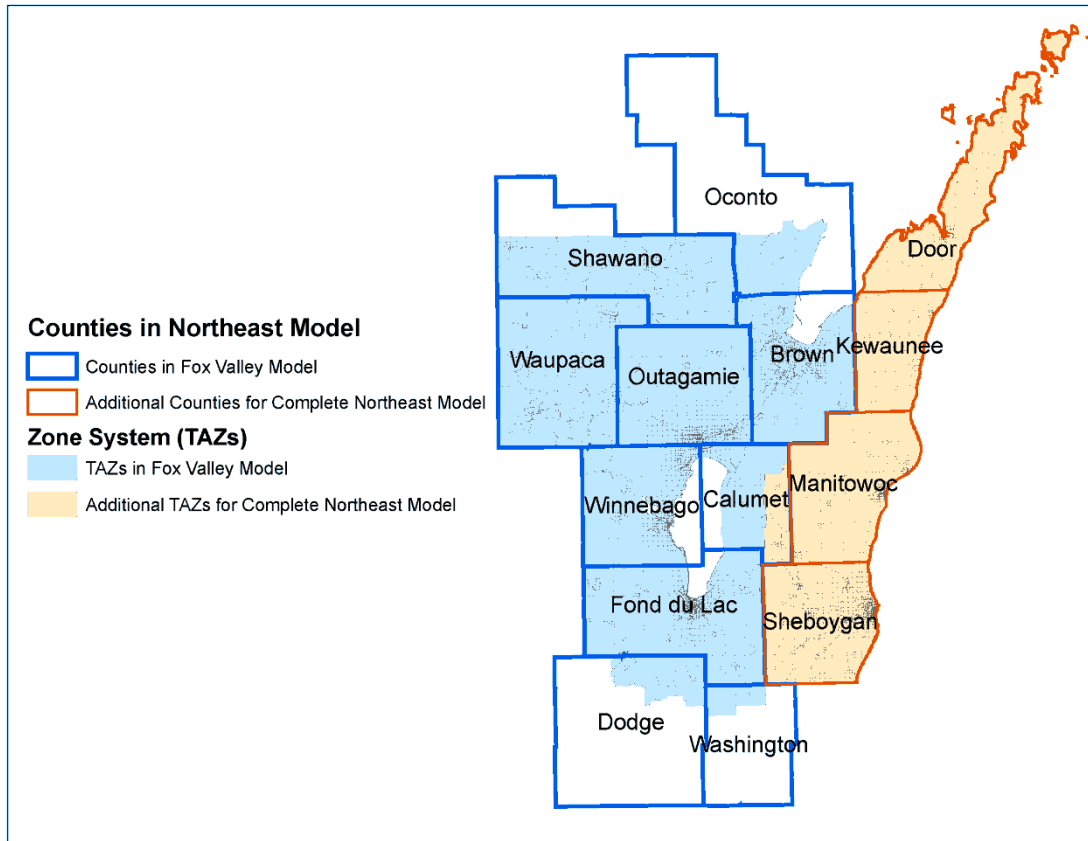


Figure 4-1. Geographic scope of the NE model

## 4.2 Trip Generation Model Component

### 4.2.1 Internal Trip Generation

Truck trip generation component estimates the number of daily truck trips produced from and attracted to each traffic analysis zone (TAZ) within study region. Based on the zonal socio-economic data of each scenario (2005/2020/2035), the number of truck trips produced is estimated by truck type using linear regression models, where the truck type consists of single unit truck and combination truck,

Number of Truck Trips Produced<sub>Single</sub> =

Number of Households × Household Rate<sub>Single</sub> +

Number of Retail Employment × Retail Employment Rate<sub>Single</sub> +

Number of Non-retail Employment × Non-retail Employment Rate<sub>Single</sub>

Number of Truck Trips Produced<sub>Comb</sub> =

Number of Households × Household Rate<sub>Comb</sub> +

Number of Retail Employment  $\times$  Retail Employment Rate<sub>Comb</sub> +

Number of Non-retail Employment  $\times$  Non-retail Employment Rate<sub>Comb</sub>

The entire study area is separated into four regions: GreenBay, Sheboygan, Fox Valley, and the rest of the study area. Potentially, the household rate, retail employment rate and non-retail employment rate could be estimated by region. However, in the current model, generic rates are applied for different regions. The generation rates of different independent variables are summarized in Table 4-1.

Table 4-1. Trip Production Rates by Truck Type

	Single-Unit Truck Trips	Combination Truck Trips
Households Rate	0.099	0.038
Retail Employment Rate	0.253	0.065
Other Employment Rate	0.143	0.055

After calculating the number of zonal truck trips produced, the truck trip attraction is simply assumed to be equal to truck trip production,

Number of Truck Trips Attracted<sub>Single</sub> = Number of Truck Trips Produced<sub>Single</sub>

Number of Truck Trips Attracted<sub>Comb</sub> = Number of Truck Trips Produced<sub>Comb</sub>

#### 4.2.2 External Trip Generation

For base year, the traffic volume (produced/attracted) had been previously estimated using data from the Wisconsin Statewide Multimodal Travel Demand Model. This data set was updated with actual vehicular data counts in order to increase the model’s accuracy at these locations and as a result the counts were not factored. SRF, in conjunction with JT Engineering, Inc. collected additional traffic counts for 17 external sites, which are selected according to traffic volume, highway functional class and whether it is on a designated truck route. The traffic counts at these external sites, with vehicle classification, give the number of daily truck trips produced and attracted.

For future year 2035, the NE region model uses the same forecasts that were used in the Fox Valley model where available, and these forecasts cover 58 external zones. For the remaining external zones, the forecasts are determined based on the following sources: Wisconsin Statewide model, WisDOT’s TAFIS (Traffic Analysis Forecasting Information System), and count data with a constant 1.5% annual growth. Once the 2035 forecast traffic volume was determined, the 2020 external forecast were derived using an interpolation between the 2005 and 2035 volumes.

#### 4.2.3 Trip Adjustment

A trip adjustment step is used to adjust truck trip attraction for each internal zone,

$$\text{Number of Trips Attracted} = \frac{\text{Total Number of Trips Produced} - \text{Total Number of Trips Attracted}_{\text{External}}}{\text{Total Number of Trips Attracted}_{\text{Internal}}} \times \text{Number of Trips Attracted}$$

By applying the adjustment procedure, the number of truck trips attracted to each internal zone is changed in that way that the total number of truck trips attracted to external and internal zones is equal to that of truck trips produced from external and internal zones. And this procedure is applied to both single-unit truck trips and combination truck trips.

### 4.3 Trip Distribution Model Component

The trip distribution model component calculates the number of truck trips between zones by using a doubly constrained gravity models,

$$\text{Number of Trips}_{ij} = B_i \times D_j \times \text{Number of Trips Produced}_i \times \text{Number of Trips Attracted}_j \times f_{ij} \times K_{ij}$$

$$B_i = \frac{1}{\sum_j D_j \times \text{Number of Trips Attracted}_j \times f_{ij} \times K_{ij}}$$

$$D_j = \frac{1}{\sum_i B_i \times \text{Number of Trips Produced}_i \times f_{ij} \times K_{ij}}$$

where

*Number of Truck Trips<sub>ij</sub>*: Number of trips from zone *i* to zone *j*.

*Number of Truck Trips Produced<sub>i</sub>*: Number of trips produced in zone *i*.

*Number of Truck Trips Attracted<sub>j</sub>*: Number of trips attracted to zone *j*.

*F<sub>ij</sub>*: Friction factor from zone *i* to zone *j*.

*K<sub>ij</sub>*: K-factor, set to the value of 1.

The friction factor in the gravity model measures the attractiveness for traveling from zone *i* to zone *j*. An exponential form of the impedance function is applied in the model as follows:

$$f_{ij} = e^{-\alpha \times t_{ij}}$$

where

*α*: truck trip distribution parameters by truck type, as shown in Table 2.

*t<sub>ij</sub>*: travel time from zone *i* to zone *j*.

The friction factors are set to be zero for external-external trips.

Table 4-2. Truck Trip Distribution Parameters *α* by Truck Type

Single-Unit	Combination
0.1	0.03



After the trip distribution step, the number of daily truck trips between each origin and destination (OD) pair is split into four numbers corresponding to four periods in a day, including AM (6AM-9AM), midday (9AM-3PM), PM (3PM-6PM) and night (6PM-6AM). The number of truck trips in each time period is obtained as the product of number of daily truck trips and each corresponding time of day factor:

Number of Truck Trips between  $OD_{AM}$  = Number of Daily Truck Trips between OD × AM Split Factor

Number of Truck Trips between  $OD_{MD}$  = Number of Daily Truck Trips between OD × Midday Split Factor

Number of Truck Trips between  $OD_{PM}$  = Number of Daily Truck Trips between OD × PM Split Factor

Number of Truck Trips between  $OD_{NT}$  = Number of Daily Truck Trips between OD × Night Split Factor

Different sets of time of day factors are applied for single-unit truck and combination truck types, where the factors are summarized in Table 4-3. According to the ECWRPC staff, the source of these split factors is not clear but the values reasonably reflect what are on the ground.

Table 4-3. Time of Day Factor by Truck Type

	Single-Unit Truck Trips	Combination Truck Trips
AM	0.200	0.123
Midday	0.357	0.220
PM	0.255	0.157
Night	0.188	0.500

#### 4.4 Traffic Assignment Model Component

During the traffic assignment step, the O-D single-unit and combination truck trips by time period are allocated together to highway network links, resulting in highway links loaded with truck trips. In the current NE model, the trucks are first assigned on the free flow network, in which some links are set as being truck-prohibited to account for the fact that truck traffic is not allowed in some urban areas or on local roadways. After assigning truck trips, the auto trips are then assigned on the same network loaded with truck trips. One truck is considered to have the same impact as 1.5 autos on the network.

A user equilibrium method is used for traffic assignment, to which the principle that “No truck can improve its travel cost by changing routes” applies. This means that trucks on all used routes between a particular pair of origin and destination will have same travel cost. In the NE model, the travel cost of a route is specified by summing up congested travel time across all links that the route consists of, and the travel time on a link is obtained from BRP equation:

$$T_C = T_0 * (1 + \alpha * (V / C)^\beta)$$

where

$t_0$ : Free flow time of the link.

$v$ : Number of hourly truck trips on the link.

$c$ : Link capacity of the link.

$\alpha, \beta$ : Parameters of BRP function specified by highway functional classes in Table 4-4.

Table 4-4. Parameter Value in BRP Function

Functional Classification	$\alpha$ Value	$\beta$ Value
1	0.30	10.0
2	0.10	12.5
3	0.30	7.00
4	0.30	6.00
11	0.80	7.00
12	0.50	6.00
13	0.15	2.1
14	0.15	2.5
21	0.90	1.4
22	0.85	10.0
23	0.90	1.0
24	0.25	2.6
25	0.15	1.5

The link-based Frank-Wolfe algorithm is used to solve the equilibrium problem. Multiple iterations are usually required before the equilibrium assignment comes to convergence, which is judged by the gap of total travel costs for vehicle volumes across all links between two iterations. Specifically, the gap at an iteration  $k$  is defined as below,

$$Gap_k = \frac{|\sum_l Vehicle\ Volume_{l,k} \times Cost_{l,k} - \sum_l Vehicle\ Volume_{l,k-1} \times Cost_{l,k-1}|}{\sum_l Vehicle\ Volume_{l,k-1} \times Cost_{l,k-1}}$$

where,

$Vehicle\ Volume_{l,k}$ ,  $Vehicle\ Volume_{l,k-1}$ : Vehicle volume on link  $l$  in iteration  $k$  and  $k-1$ , respectively.

$Cost_{l,k}$ ,  $Cost_{l,k-1}$ : Travel cost of link  $l$  in iteration  $k$  and  $k-1$ , respectively.

In the NE region model, the convergence gap is set as 0.0005, and maximum iteration number is set as 30. The equilibrium iteration will stop if one of the criteria is satisfied.

## 4.5 Feedback Mechanism

Since there is no traffic loaded on the highway network in the initial trip distribution step, the travel time between zones  $t_{ij}$  is free flow traffic time that doesn't reflect the actual attractiveness or impedance between zones. A feedback loop is incorporated into NE region model to account for the effects of actual traffic on distribution procedure.

Specifically, after loading the truck trips and auto trips on highway network, the model starts over from trip distribution and uses the travel time calculated from loaded network. Then the time of day split component and traffic assignment component are repeated based on the updated trip distribution table. For the feedback iteration, the base year (2005) run is set to 4 iterations and the future year (2020 and 2035) runs are set to 7 iterations.

## 4.6 Discussion and Recommendations

Based on the research team's assessment, NE Model v.11 is an operational model that reasonably replicates at least the base year traffic pattern in the region. The modeling methodology follows that of the Quick Response Freight Manual (QRFM) II, which is also the standard practice adopted by many transportation planning agencies around the country. However, it is also well recognized that QRFM-based models are limited in sensitivity to a broader range of policies and trends discussed in Section 1.1.

This section discusses the limitations found in the NE Model and ways of enhancing the model. Some of the recommendations are incremental improvements and are feasible for the agency to adopt in the near term, mostly at the cost of collecting additional data. Other recommendations would be considered as more drastic and long-term investment, involving the agency to embrace the state-of-the-art modeling approach and secure the necessary funding and resources.

### 4.6.1 Incremental Improvements

#### Calibrate the model with local data.

As evident in the NE model scripts and documentations, most of the parameters used in the truck modeling components are borrowed from the Phoenix Metropolitan Urban Truck Model. However, as stated in the QRFM, “[t]he borrowing of truck trip rates is a very common practice due to the lack of good survey data. This should, however, be done with caution. Almost one-half the urban truck models across the nation are based on the 1992 Phoenix metropolitan area truck model. The current QRFM recommends using the trip rates and gravity models from this model as a starting point, and then calibrating the parameters until they validate well with observed local count data. .... The best way to estimate truck-model parameters is by collecting data through truck travel surveys.”

The survey data collected through methods developed as part of this project (see **Error! Reference source not found.**) is valuable for calibrating components of a 3-/4-step aggregate model. If resources are available to expand similar data collection effort to produce large enough a sample size across the NE region, the survey data could be used to greatly enhance the quality of the NE model.

### Refine industry classification in trip generation equation.

Currently, the independent variables used in the trip generation model (which takes the form of linear regression equations) include the number of households, number of retail employment and number of non-retail employment. Potentially, the non-retail employment could be further disaggregated into the three categories as defined in the Phoenix model (Agriculture, Mining and Construction employment; Manufacturing, Transportation/Communications/Utilities and Wholesale Trade employment; and Office and Services employment) and be assigned with different trip generation rates. The rates could either be estimated using local data or be borrowed from the QRFM II. The more refined treatment of industry classification in the model is expected to improve the model's forecasting capability (assuming that the rates are spatially and temporally transferable from Phoenix to NE WI). This enhancement is especially important if the mix of non-retail industries changed significantly in the study area between the base year and the forecast year.

### Apply location-specific treatment in trip generation

If local data becomes available, it would be beneficial to estimate trip generation rates separately for the different regions (namely, Green Bay metropolitan area, Sheboygan metropolitan area, Fox Valley metropolitan area, and the rest of the study area) represented in the model.

Any special freight traffic generators, such as the Port of Green Bay and Brown County Airport, may also warrant explicit treatment by incorporating dummy variables in the regression equations. However, when forecasting the truck trip generation for future years, caution needs to be exercised when the special generators are no longer present or new type of special generator become present.

### Incorporate additional variables in trip generation

Ultimately, a more behaviorally-realistic and policy-sensitive trip generation model would be defined in terms of explanatory variables that have more direct correlation with the amount of truck trips generated. Possible variables include total floor size, total capacity of distribution centers, and transportation accessibility. More local data and further empirical analysis would be required to determine a more advanced trip generation model that has good statistical fit and sound behavioral foundation.

### Adjust terminal time in trip distribution

Before trip distribution, the network skim procedure computes the travel time between each origin and destination pair as the sum of the travel time between the zones and the terminal travel time (defined as the time spent traveling to/from the final destination within the zone). The terminal time used in the NE model is simply assumed to be 1 minute for truck trips. However, depending on the land use setting and the size of a zone, the terminal time could vary significantly. As suggested by QFRM, "the terminal times may be adjusted as part of the trip distribution model calibration process in order to make the average trip lengths produced by the model more closely match the observed average trip lengths."

### Refine truck conversion in traffic assignment

Currently, a common “passenger car equivalence” factor of 1.5 is used for all trucks in the NE model’s traffic assignment procedure. However, the single-unit trucks and combination trucks could be treated separately in order to reflect the effect of heavier vehicles on congestion. The QFRM suggests the values of 1.5 and 2.0 for single-unit and combination trucks, respectively. However, the impact of this modification on the overall model outcome is probably limited.

#### Adjust convergence criteria in traffic assignment

The convergence of the assignment procedure is currently determined by the gap value that is computed based on the total vehicle travel cost between iterations. However, it is theoretically possible, and not uncommonly found in practice, that the gap value may fall below the threshold before the algorithm converges properly and the link performance measures become stable. An alternative, and perhaps more effective, measure for convergence is the relative gap between iterations.

#### Incorporate a mode split model component

The current NE model does not consider freight modes other than trucks. Considering the presence of freight rail and ports in the region, incorporating these alternative modes in the model and expanding the three-step model to a four-step model would enhance the validity of the model. Such an enhancement will also better support policy design and investment decision making regarding alternative freight modes and intermodal facilities. Introducing a mode split component for the NE model would require a better (qualitative and quantitative) understanding of the current level of utilization of non-truck modes in the area and the circumstances for businesses to consider doing so in the short-run.

### 4.6.2 Long Term Investments

#### Adopt the commodity-based modeling approach

A typical commodity-based model consists of commodity generation, commodity distribution, mode split and traffic assignment. The commodity generation and distribution steps closely resemble the trip generation and distribution steps in the existing NE model. However, instead of estimating number of trips produced and attracted, this procedure estimates the tonnage of commodities generated. In the mode split step, the tonnages of commodities are converted to number of truck trips or trips of other modes.

The commodity-based modeling approach would better capture the commodity movements between zones in the NE region. In a commodity-based model, the trip purpose is replaced by commodity type. Given an appropriate commodity-type classification and coverage in the model, the commodity-based model is more likely to produce a better representation of the underlying economic activities than truck trip-based models would. This leads to improved policy sensitivity, allowing transportation investment decisions to be made in light of future economic trends.

Calibrating and estimating a commodity-based model would, of course, require additional data sets that have not been used to develop the current NE model. These data sets include:

- Commodity Flow Survey (CFS) or local survey to estimate tonnage of commodities produced and attracted at each zone.
- CFS, Transearch or local survey to provide information about commodity exchange between zones.
- Mode split table to determine the mode used for commodity shipping.
- Truck size to determine the vehicle conversion factor, which converts tonnage of commodity into number of truck trips.

#### Adopt the firm/tour-based modeling approach

The next step up from the commodity-based approach is the establishment of a firm-based approach, where each freight stakeholder is individually represented in the model and their transportation-related decisions are explicitly modeled. Compared to the commodity-based approach, the firm-based approach would allow more opportunity to explicitly model the decision-making driving the freight transportation pattern as we see it. The result is therefore a more policy-sensitive tool to forecast future transportation patterns under alternative regulations, infrastructure improvements, land use changes, demographic shifts, etc.

The modeling framework proposed in this study and presented in CHAPTER 3 of this report represents a highly disaggregate and complex firm-based model that focuses on capturing inter/intra-firm interaction and other supply chain concepts. While it is critical to keep moving this research field forward by investing effort to continue pushing the envelope in freight modeling, the research team also recognizes that most planning agencies are not yet ready to fully embrace advanced demand forecasting models for at least three factors. First, microscopic models are often computationally more expensive than the conventional models, thus rendering them impractical for agencies who have limited resources. Second, although theoretically appealing, these advanced models remain to be thoroughly validated and their forecasting capabilities evaluated against conventional models. As this validation and evaluation process requires data-intensive back-casting, the process in this area has been slow. Third, and as the result of the previous two factors, few of such advanced models are fully operational and even fewer can be used to meet planning legal requirements. Recognizing these three factors, we offer an alternate firm-based modeling approach that represents a compromise between the conventional trip-based model and the highly complex firm-based model.

The premise of this alternate modeling approach lies in incrementally “stripping down” the conventional trip-based model while incorporating more behavioral realism one model component at a time. As depicted on the right-hand-side of Figure 4-2, the “simplified” firm-based model would focus on incorporating freight stakeholders’ behavioral elements that are most relevant to the accurate prediction of the spatial movement of truck traffic. Two levels of logistic decisions would be considered: tactical and operational. Tactical decisions include decisions of firm locations, distribution center/warehouse locations, retail store locations, use of 3PLs, etc. Operational decisions include delivery times or time windows, costs relating to early/late arrivals, route choice, etc. Other logistic elements such as inventory capacity, customers’ quantities of goods demanded, shipment size, and vehicle type would be considered as exogenous in this framework to keep the model scope manageable.

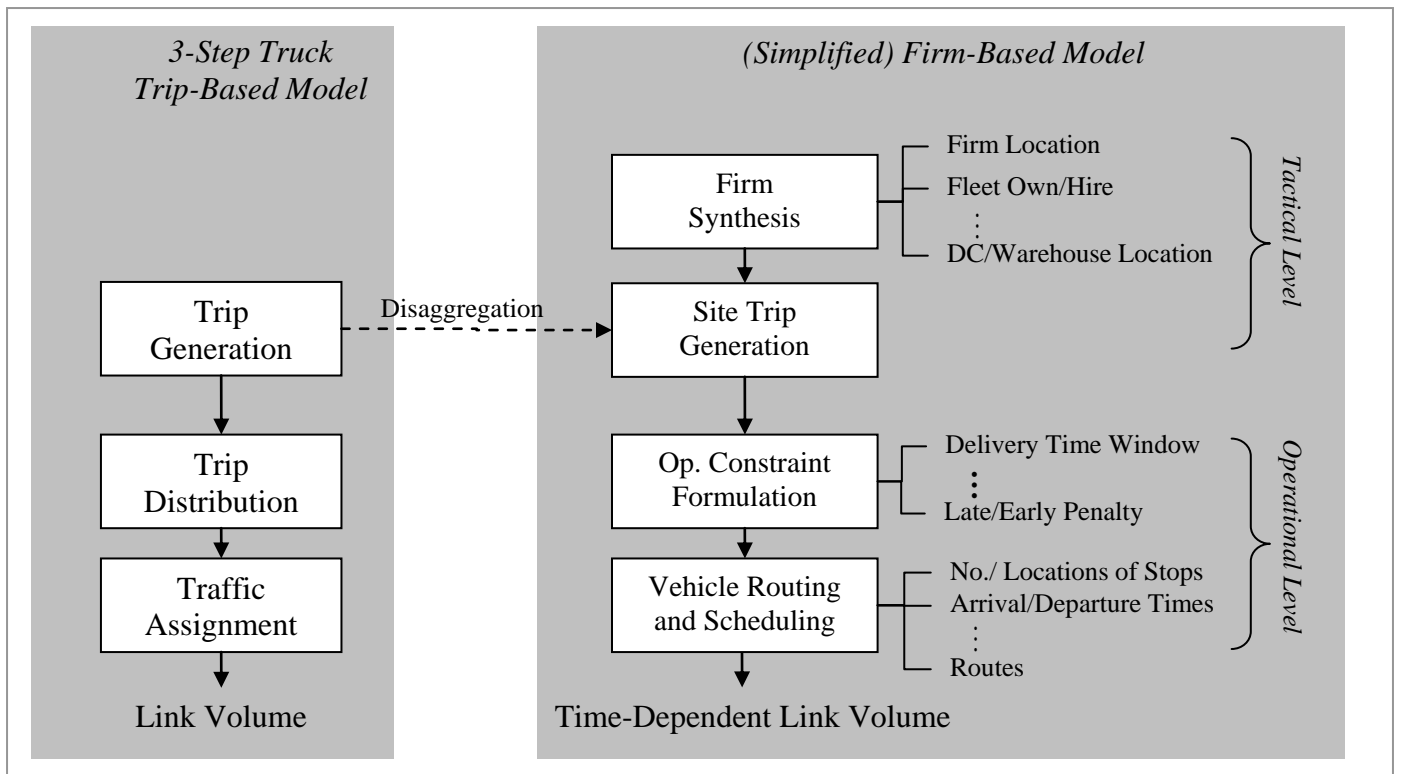


Figure 4-2 Moving from a conventional three-step truck trip model to a firm-based model

The model as outlined in Figure 4-2 is a novel concept that needs to be further developed and researched. It is the research team's belief that such a framework is more ready for practice and could significantly enhance our ability to forecast freight transportation.

## **CHAPTER 5. DATA REVIEW AND COLLECTION**

The modeling framework proposed in CHAPTER 3 incorporates various logistic decision making processes at both firm and establishment levels and is therefore data-hungry in nature. The calibration of the model would rely on not only existing public and private databases, but also specific data to uncover the mechanisms of business logistics operation. Several recommendations presented in CHAPTER 4 for enhancing the existing NE Model also calls for more and new data.

This chapter describes the data synthesis conducted as part of Task 5 of this study to identify the needs and availability of data for conducting qualitative and quantitative analysis of stakeholder logistics decisions. These data could also be used to implement our recommendations for the NE Model. The summary of existing data sets is presented in Section 5.1. Also included in this chapter are descriptions of two data collection methodologies developed as part of Task 6 of this study. Section 5.1 presents the design and pretest of a mail-out-mail-back survey of business establishments. This survey is specifically designed to provide the data necessary for calibrating the firm-based freight model proposed in this study. Section 5.3 describes the telephone survey targeting at manufacturers in Brown County, WI. The purpose of this telephone survey is to verify the quality of the trip generation component of the NE Model and to shed light on how the model could be improved.

### **5.1 Existing Data**

Table 5-1 summarizes the data sets, if exists, that could be used to estimate/calibrate the modeling system described in Section 3.4. For each model component identified in the 1<sup>st</sup> column, the data needs and potential sources of such data are respectively outlined in the 2<sup>nd</sup> and 3<sup>rd</sup> columns of the table.



Table 5-1. Existing data sets identified for estimating and calibrating the proposed firm-based freight model

Model Component	Data Requirement	Data Sources for Model Development
firm synthesis and establishment synthesis	distribution of employment size, economic activities, sales amount, etc. for establishments and firms in study area.	U.S. Economic Census, County Business Pattern
firm vertical integration level estimation, establishment selection	disaggregated data identifying the ownership of establishments within a firm, industry input-output data identifying the trade flows between industries	Longitudinal Business Database, Input-Output accounts, InfoUSA business database
facility location choice	socio-economic data and land use information (e.g., population, median income, employment composition, etc) of traffic analysis zone (TAZ), disaggregated establishment data specifying the locations of establishments	Longitudinal Business Database various national and local database, such as U.S census, Longitudinal employment and household dynamics (LEHD, environmental planning data, etc.
commodity demand and supply	establishment information, annual quantities of inbound/outbound commodities by product type	inferred from aggregated Commodity Flow Survey database
internal sourcing external sourcing	annual commodity flows between establishments by product type	N/A
order quantity and frequency order	typical order quantity, commodity characteristics, inventory characteristics of commodities	N/A
order time assignment	order schedule, commodity characteristics	N/A
carrier selection	characteristics of third party logistics service provider	Longitudinal Business Database
transport chain selection	multi-modal transportation network characteristics such as distance, travel time,	transportation network data, e.g., HPMS database
vehicle type selection	commodity characteristics, transport assets of a firm, vehicle type selection	N/A
vehicle routing	vehicle route choice	N/A

## 5.2 Firm-Based, Mail-Out Mail-Back Survey

As revealed in Table 5-1, most of the existing data sources do not support decision estimation at firm or at establishment level because of the data being at the aggregation level. Therefore, a firm-based survey is proposed in this study to collect the necessary additional data. This section describes the instrument designed for the survey and the preliminary findings from pretesting the instrument.

### 5.2.1 Survey Questionnaire

This survey is firm-based, as opposed to facility-based, because our proposed modeling framework features a firm-based approach that recognizes intra-firm interactions. As such, the survey instrument is designed to collect more information than what is typically asked in an establishment survey. The questions asked include operation information of establishment and parent-firm, characteristics of purchase decisions and inbound shipments, and characteristics of inventory management and outbound shipments. The survey instrument also includes a truck diary of selected shipments. The instrument underwent several rounds of revisions based on input from a number of logistic experts and freight stakeholders.

Shown in APPENDIX A is a sample of the materials used for pretesting the survey instrument with a participating business. The materials include:

1. Cover letter
2. Main survey questionnaire
3. List of the firm's establishments in Wisconsin
4. Truck diary
5. Transportation mode code
6. NAICS industry code
7. Survey feedback questionnaire

### 5.2.2 Lessons Learnt through Pretesting

The survey instrument was pretested with a small number of establishments in the Green Bay and De Pere area. The pretest was administered by a consultant hired for this project. The participating establishments were recruited by the consultant over the phone and included two wholesaler and several manufacturers of different industries and sizes. Once recruited, the establishments were mailed a package of print materials listed in APPENDIX A (with some customization of the forms). Detailed instructions were given on the cover letters regarding when the forms should be completed and how the consultant would follow up with a face-to-face interview. During the post-survey interviews, the consultant went through the completed forms with the participants and asked clarifying questions. In particular, the consultant probed the participants about their responses on the feedback questionnaire to gain insight into the survey experience. These interviews provided valuable feedback to the research team regarding whether and why the survey instrument worked or didn't work. Below is a list of our key findings through this pretest process.

- It took the participating businesses 15 minutes (a smaller manufacturer) to 3 hours (a major wholesaler with many facilities in WI and a large truck fleet) to complete the survey questionnaire. Although the pretest participants completed most of the questionnaires, the

length and complexity of the survey are obviously a concern and may significantly impact the response rate when the survey is fully deployed. This suggests that an aggressive advertising campaign, endorsement from relevant agencies, and support from business associations will be critically important.

- Questions on the firm's structure, assets, and warehouse operation were generally easy to understand and to answer. Most participants experienced difficulty in providing information regarding the inbound and/or outbound commodities. For wholesalers, the difficulty lies in the fact that they purchase *many* different commodities, each of which could come from *many* different suppliers. For manufacturers, the difficulty arises when the company (in this case, an auto parts supplier) has many non-repeat customers and ships their products in parcels using carrier services. This suggests that the questions in sections 3 and 4 need to be further tailored to suit the operation of the participating company.
- The current questionnaire appeared to work better for manufacturers. Separate forms are needed for the wholesalers. Agriculture and mining industries may also need some tailoring since these firms tend not to make regular purchases as manufacturers and wholesalers do.
- Surprisingly, most of the respondents rated the survey questions non-sensitive. A couple of respondents were more cautious about providing information on outbound than on inbound commodities.
- Some of the respondents expressed difficulty in relating to the current truck type classification. All, except a wholesaler, found the industry code easy to use. An issue surfaced regarding the industry code was that certain commodities (such as food) could either come from a wholesaler or directly from a manufacturer, making it difficult for the respondent to identify a single sourcing industry for that commodity.
- Not surprisingly, the larger companies (which have separate departments for sales, purchasing, transportation, etc) required more than one staff member to provide the information needed to fill out the questionnaire. In order to reduce survey burden in this regard, we could put the four sections of the questionnaire on four separate forms. Or, arrange the layout of the questionnaire so that each section starts on a new page to make it easier for a respondent to forward the questions to the suitable departments.
- Discrepancies were found between what some of the establishments reported and the information obtained from the InfoUSA business listing (e.g., annual sales amount, number of employees, square footage). This suggests that the basic questions about the establishment are still warranted. An alternate approach is to verify the basic information during the recruiting stage and remove these questions from the main survey questionnaire.
- Companies that have their own truck fleet tend to find the truck diaries easy to administer.
- Paper-based, mail-out mail-back approach was preferred over email or on-line surveys.

Based on the findings from the pretest, the research team believes that the instruments developed thus far for the firm-based survey provides a good starting point for a workable

survey. However, more resources and time are needed to further improve the instruments to address the issues identified during the pretest. Also, the time and resources required to successfully campaign this survey and to collect enough data for meaningful statistical analysis would be beyond what this project could afford. Therefore, we did not further pursue the firm-based survey as part of the present study.

### **5.3 Telephone Survey with Manufacturers**

The objective of this telephone survey of manufacturers is to collect quantitative data to help verify the quality of the trip generation component of the NE Model and to shed light on how the model could be improved. The decision of focusing on manufacturers was made based on two major factors. First, manufacturing represents the industry sector that generates the most truck trips in the NE region. Second, the research team was more successful in the design of firm-based questionnaire for manufacturers than for other sectors. The telephone survey can build on that experience. Early on the decision was also made to contact *all* the manufacturers in the Brown County area, as opposed to randomly selected manufacturers throughout the NE Model region. This was motivated by the desire to focus our remaining resources on a smaller geography so as to reduce “noises” in the data collected. Furthermore, Brown County has the highest number of manufacturers than other counties in the NE Model region (see Figure 5-1).

#### **5.3.1 Survey Questions**

This telephone survey is unique in that the questions are designed to better understand the *dynamics* or fluctuations in trip generation pattern. This is because past freight models have all been designed to represent freight movement on a “typical” weekday. However, our face-to-face interviews and paper-based survey pretest revealed that companies do not necessarily ship or receive on a regular basis. The amount of goods shipped on each trip may also vary greatly. If this was indeed the case for most companies, then modelers would need to reconsider the conventional practice of modeling a “typical” day. This telephone survey is therefore designed to assess the extent to which shipment quantity and/or frequency vary from day to day.

As shown in APPENDIX B, the manufacturer’s shipping activity survey includes up to 18 questions, which typically takes no more than 10 minutes.

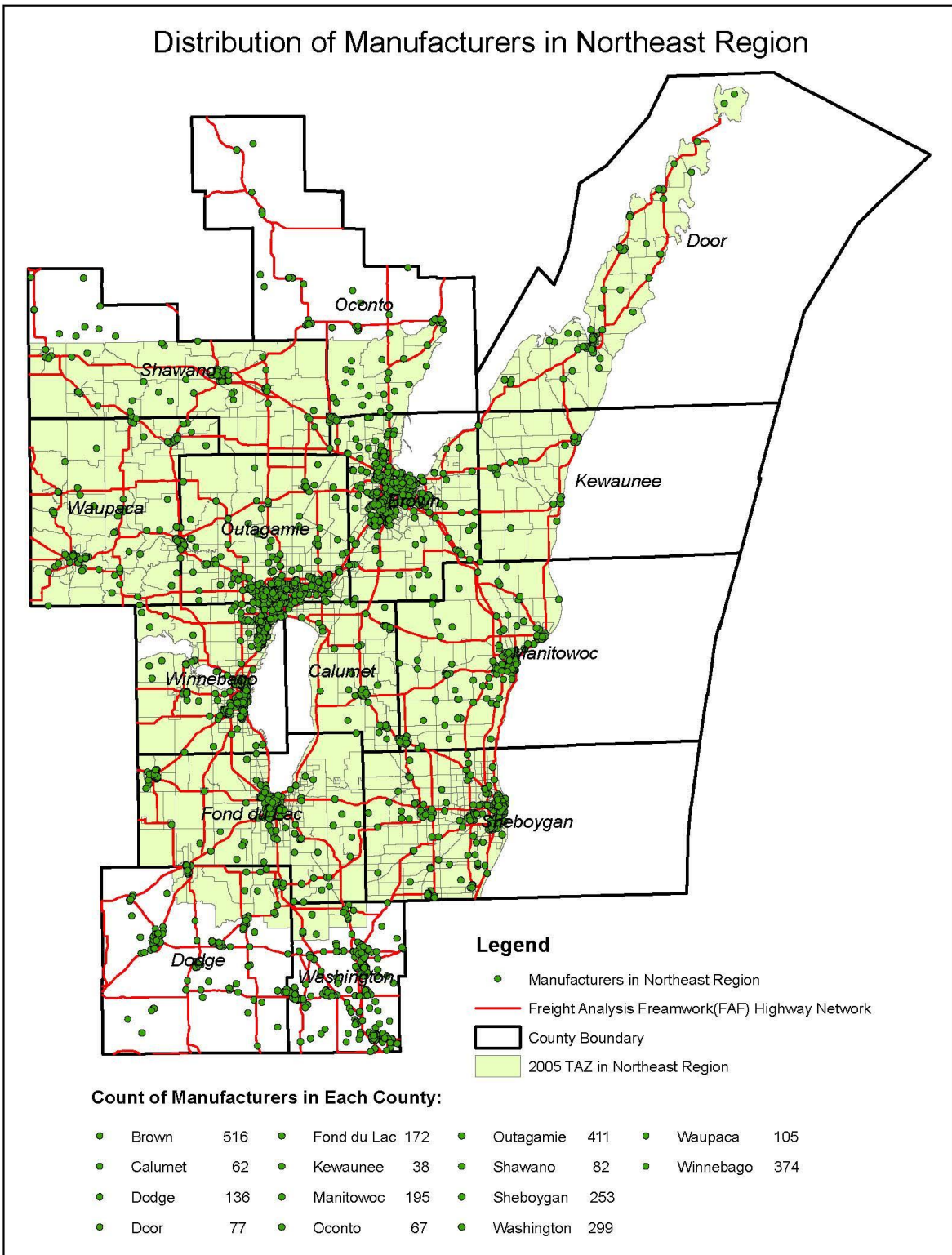


Figure 5-1. Distribution of manufacturers in the NE Model region.

### 5.3.2 Data Collection

The calling list contained all 516 companies in the InfoUSA business database whose primary NAICS code indicate manufacturing industry and who are located in the Brown County. The survey questions were scripted and set up in Qualtrics, an online survey administration tool, so that telephone interviewers could enter survey responses on the fly. Calls were typically made during 9:30 am~11:00 am and 1:30pm~3:00pm, which appear to be the non-rush hours for shipping activities. If the first attempt was not answered, a second attempt would be made within the week. If the call was connected but did not reach the person in the company responsible for shipping activities, the caller would ask for a more suitable time to phone back and would make another attempt at calling the right person. 15% of the phone numbers on the calling list were inactive or wrong numbers. 42% of the companies refused to participate in the survey. The calls did not get hold of the person in charge of shipping in 35% of the companies within two attempts. Only 8% (41) of the companies participated in the survey. This response rate is comparable to that of past paper-based freight surveys, but lower than typical telephone surveys. This lower-than-average response rate is at least partially attributed to that call-back attempts were limited to two per company. Characteristics of the final sample are presented below while more in-depth analysis of the sample is presented in the next chapter.

### 5.3.3 Sample Characteristics

As shown in Table 5-2, the manufacturers that responded to our telephone survey have a lower average sales volume than the county average across all manufacturers and this difference is statistically significant. Since sales volume is very likely and positively correlated to the amount of goods being shipped, this difference suggests a possible downward bias in the trip generation rates picked up in the survey sample. The difference between the manufacturers in the sample and in the population is small and statistically insignificant in terms of number of employees in the establishment, distance to the nearest highway ramp (as a measure of accessibility), and a number of TAZ-level land use attributes.

Table 5-2 Comparison of salient characteristics between the sample universe and the respondents

	All Manufacturers in Brown Co.	Manufacturers in Final Sample
Number of Employees in Establishment		
Average	36.09	26.78
Standard Deviation	131.36	33.14
Annual Sales Volume		
Average	\$15,010,378	\$6,401,056
Standard Deviation	\$120,867,560	\$7,725,997
Distance to Nearest Highway Ramp (in meter)		
Average	1856.9	1478.8
Standard Deviation	1431.7	642.7
Number of Households in TAZ		
Average	287.4	254.1
Standard Deviation	262.7	212.7
Number of Retail Employment in TAZ		
Average	112.6	79.9
Standard Deviation	208.9	80.2
Number of Service Employment in TAZ		
Average	245.5	206.6
Standard Deviation	291.4	211.8
Total Number of Employment in TAZ		
Average	1057.7	919.4
Standard Deviation	950.4	654.4
Population Density in TAZ		
Average	2822.7	3019.0
Standard Deviation	4822.8	3123.2

## CHAPTER 6. EMPIRICAL ANALYSIS

This chapter reports the two major pieces of empirical analysis conducted in this study. The first piece of analysis is based on the proprietary InfoUSA business database. The objective of the analysis is to better understand the operations of the freight stakeholders in the NE Model region. The analysis findings could be beneficial to ECWRPC’s planning activities in general and also help ECWRPC assess the necessity and feasibility of implementing some of the recommendations outlined in Section 4.6.

The second piece of analysis reported here is based on the sample data collected through the telephone survey described in Section 5.3. The objective of the analysis is to bring new light on the shipping pattern and provide pointers for improving the truck trip generation component of the NE Model.

### 6.1 Business Patterns in NE Wisconsin

Table 6-1 and

Table 6-2 show the distribution of single- versus multi-location businesses in the NE Model area by primary NAICS industry type and employment size. The tables reveal that multi-location firms are quite prevalent in the study area, suggesting that the model capability of representing the differential behavior of single- and multi-location firms would be relevant to the region.

Table 6-1. Distribution of single-location firm (establishments) in NE Model area

	Missing Employees Info	1-4 employees	5-19 employees	20+ employees	Total
Agriculture	1	837	203	39	1080
Mining	0	35	8	7	50
Manufacturing	0	969	786	645	2400
Wholesale Trade	0	1049	703	270	2022
Truck Transportation (NAICS4841,4842)	0	273	137	88	498
Warehousing and Storage (NAICS 4931)	0	59	25	10	94

Table 6-2. Distribution of establishments in multi-location firms in study area

	Missing Employee Info	1-4 employees	5-19 employees	20+ employees	Total
Agriculture	0	3	2	2	7
Mining	0	4	2	0	6
Manufacturing	18	44	78	257	397
Wholesale Trade	4	88	145	112	349
Truck Transportation (NAICS4841,4842)	4	9	19	28	60
Warehousing and Storage (NAICS 4931)	0	6	4	7	17



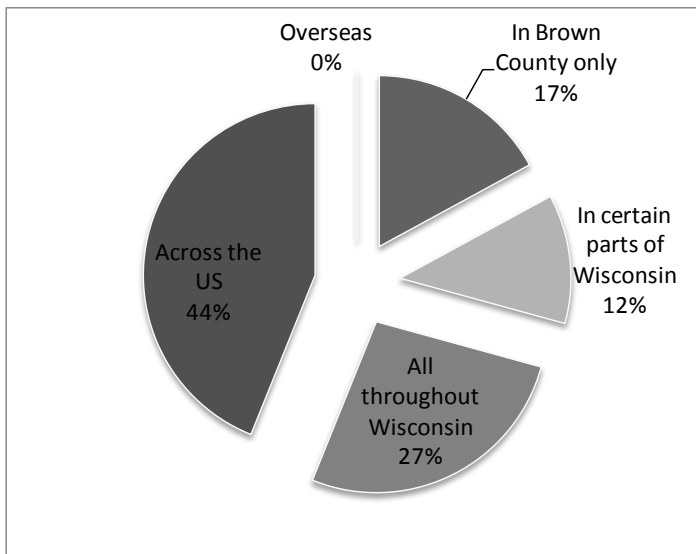
Table 6-3 shows the distribution of establishments by county and industry sector. Brown county clearly houses the highest number of establishments across all sectors of industry. While the manufacturing industry is highly represented in most counties, Kewaunee and Shawano counties have higher proportion of agricultural businesses than other counties. The variation in the mix of various industry types across counties further supports our recommendation of treating these industry sectors separately in the trip generation equation (as opposed to aggregating these industry types into a single “non-retail” category and applying an uniform generation rate) of the NE Model.

Table 6-3. Distribution of establishments by county and primary NAICS industry type

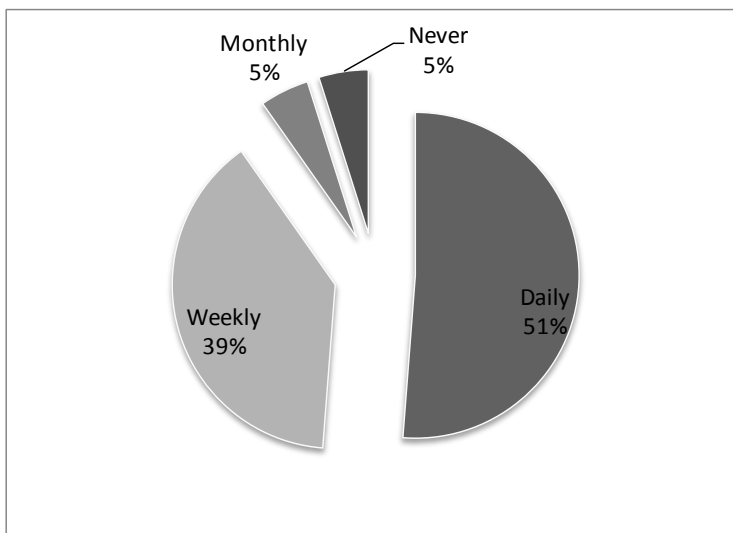
County	NAICS Industry Type						Total
	Agriculture	Mining	Manufacturing	Wholesale Trade	Truck Transportation	Warehouse	
Brown	119	9	516	543	112	32	1331
Calumet	53	4	53	48	9	3	170
Dodge	79	2	123	97	34	10	345
Door	39	3	77	61	7	2	189
Fond du Lac	103	7	179	167	61	4	521
Kewaunee	51	1	38	33	6	0	129
Manitowoc	93	3	196	131	47	3	473
Oconto	54	3	64	54	26	1	202
Outagamie	105	7	419	441	60	17	1049
Shawano	100	3	78	70	22	3	276
Sheboygan	69	3	251	156	46	8	533
Washington	63	4	306	220	66	9	668
Waupaca	89	2	137	106	24	1	359
Winnebago	70	5	360	244	38	18	735
<b>Total</b>	<b>1087</b>	<b>56</b>	<b>2797</b>	<b>2371</b>	<b>558</b>	<b>111</b>	<b>6980</b>

## 6.2 Shipping Pattern of Sampled Manufacturers in Brown County

### 6.2.1 Primary Location of Customers



### 6.2.2 Frequency of Outbound Shipping



### 6.2.3 Frequency and Nature of Recent Outbound Truck Trips

- When asked about the total number of truck trips made out of their facility within the past 7 days, 3 out of the 41 respondents did not provide a response. 2 of the remaining respondents reported having made 0 outbound trips. The average of the remaining 36 manufacturers is 14 trips, with the maximum being 50 trips and minimum being 2 trips.
- When asked about the last day when they had any outbound shipments, those manufacturers that ship daily all reported “yesterday”. The responses from the manufacturers who ship weekly were fairly evenly distributed from 1 to 7 days ago, suggesting that shipping

activities are not more intense for any particular day of the week. The highest number of days reported was 39 days ago and was from a manufacturer that ship monthly.

- When asked about the number of outbound truck trips on the day when they last had outbound shipments, 3 out of the 41 respondents did not provide a response. The average across the manufacturers who responded was 1.9 trips, with a standard deviation of 1.2. The highest number of trips was 5.
- Up to 2/3 of the respondents were unable or unwilling to provide information regarding the total value and/or weight of their outbound shipments on the day when they last made outbound shipping. Had this information been more accessible, it may be possible to develop annual sales to trip frequency conversion rates by industry (at, say, 3-digit NAICS code level) as a way to estimate trip generation.

#### 6.2.4 Outbound Shipping on the Busiest Day

- When asked about the number of outbound truck trips on their busiest day in 2011, most of the responses deviate significantly from what was reported on the most recent shipping day. The average was 5 trips, with a standard deviation of 4.3 and the maximum being 15 trips.
- The difference in trips generated between the most recent shipping day and last year's busiest day range from 0 to 14 trips (0% to 1400% increase).
- About half of the respondents indicated that their busiest day could fall in any month of the year. ¼ of the respondents reported Sep/Oct were their busiest months. The remaining respondents did not provide a valid answer.

#### 6.2.5 Summary

The findings in Sections 6.2.3 and 6.2.4 were particularly interesting and provided support to our postulation that shipping activities could vary significantly from day to day. The size of our sample data is unfortunately too small to ascertain any specific seasonal trends for any particular industry sector or in the overall shipping pattern. The size of the sample data also does not support any further multivariate analysis or estimation of trip generation models.

However, our findings do highlight the need for further investigation into the extent of freight demand fluctuation across different times of the year. Such an investigation is important because the conventional freight models, by design, represent an “average day” over highly aggregated classification of shippers. If our freight demand forecasting tools are to be used to analyze the impact of policies that are more relevant to some industry sectors than others and during certain period of the year (e.g. those utilizing heavy trailers in icy/snow conditions), then these tools need to be able to properly reflect the conditions under which the policies would be most relevant. Furthermore, the emerging need of improved risk management in transportation also calls for planning tools that allow decision makers to assess worst scenarios. While the subject of day-to-day dynamics in travel patterns has received increasing attention among the passenger demand modelers, very little has been done in this area in freight demand modeling. One way of moving forward is to conduct more extensive surveys similar to the one reported in this project and examine shippers' data against truck GPS data that is becoming more and more accessible.

## CHAPTER 7. SUMMARY OF STUDY

The primary goal of this study was to gain a deeper understating of freight decision-making processes and of the interaction among private stakeholders so as to inform the development of policy-sensitive freight demand forecasting models. The study began with a scan of recent literature on freight demand modeling. The studies were critically reviewed and summarized in terms of behavioral principles assumed, methodological structure, data source and study area.

In view of the inappropriate treatment of multi-establishment firms in previous freight demand models, this study sets out to consider a firm-based modeling approach that incorporates supply chain concepts and accounts for the interdependency of establishments within a firm. The development of this firm-based approach began with outlining an initial conceptual framework developed that represents all elements of logistics management driving a firm's freight transportation demand. This includes decisions ranging from production/consumption decisions, to supply chain and inventory replenishment, shipment origin, destination, content, timing, quantity, mode, and routing decisions. A series of face-to-face interviews were then conducted to gain further insight into certain aspects of freight stakeholder behavior and to help guide our next steps in our model development effort. The interviews helped confirm the postulation that intra-firm coordination is an on-going trend within which the freight system operates. In fact, collaboration across firms is also emerging and could have a direct impact on fright movement and how we collect movement data. The interviews further revealed the very heterogeneous nature of firms in terms of not only what they do, but also their business model, history, philosophy, and supply chain context. As such, seemingly similar businesses could have very different ways of making their freight-related decisions. The conventional truck trip based models conveniently overlook, or aggregate away, all these behaviorally details. Yet, many of the freight issues that we face today call for freight forecasting tools capable of representing these emerging trends and heterogeneous decision-making paradigms. In response to this call, this study developed a novel firm-based framework for modeling freight demand.

Our proposed modeling framework outlines *who* decide on *what* aspects of freight movement and *how* does the decision relate to *which* policy/design variable. It considers freight demand in the context of supply chain and logistic considerations. At the heart of the modeling framework is the recognition that freight transportation demand is derived from business logistics decision-making. The proposed framework, which is not yet estimated or operational, is aimed at bridging a critical gap in the existing body of literature on freight demand modeling. To the authors' best knowledge, this framework is the first attempt among freight demand modeling efforts to examine freight movements through the distribution channel from a firm's perspective. The intra-firm interdependency in logistics decision-making is captured in the proposed framework in multiple ways. First, firm-establishment relationships under various vertical integration structures are explicitly represented in the simulation framework. Second, the possibility of internal sourcing within a firm is considered. Third, when determining how any remaining unsatisfied demand of a multi-establishment firm is served by external suppliers, the popular strategy of centralized purchasing is captured through spatial interaction between establishments. Forth, joint ordering across multiple establishments of the same firm is also considered to allow for shipment consolidation. By distinguishing the behavior of single- and multi-establishment firms, the proposed framework is likely to better represent the logistics

decision-making process that govern the resulting freight movement. This could lead to improved forecasting capability, provided that all data necessary for developing the complete modeling system are available.

In parallel to our effort in pushing the state-of-the-art in micro-level freight modeling, we also critically assessed the freight component of the NE Model, which is a good representation of the conventional freight models being used in practice throughout the country. Our objective for this part of the study was to identify *practical* and *incremental* ways of enhancing the forecasting accuracy and policy sensitivity of the existing model. This is deemed very critical as the research community strives to develop and test out the advanced modeling approaches. Our final recommendations include the following list of incremental improvements that can be accomplished with a bit of “triggering” and/or more local data:

- Calibrate the model with local data;
- Refine industry classification in trip generation equation;
- Apply location-specific treatment in trip generation;
- Incorporate additional variables in trip generation;
- Adjust terminal time in trip distribution;
- Refine truck conversion in traffic assignment;
- Adjust convergence criteria in traffic assignment; and
- Incorporate a mode split model component.

Additionally, we also outlined two modeling approaches as alternative to the existing model. The first is a commodity-based model that is gaining popularity in practice. The second is a “dumb-down” version of our proposed firm-based approach that would require further investigation and evaluation.

Another accomplishment of this study is data assessment, collection, and analysis. It is well recognized that enhancing the existing NE Model and developing a new freight demand model both require more data than what is available today. Therefore, the data requirements for estimating/calibrating the proposed modeling system were first identified. Existing public and proprietary data are then identified. A mail-out mail-back survey is then designed to meet remaining data needs. This survey is firm-based, as opposed to facility-based, because our proposed modeling framework features a firm-based approach that recognizes intra-firm interactions. As such, the survey instrument is designed to collect more information than what is typically asked in an establishment survey. The questions asked include operation information of establishment and parent-firm, characteristics of purchase decisions and inbound shipments, and characteristics of inventory management and outbound shipments. The survey instrument also includes a truck dairy. The survey instrument was pretested with a small number of establishments in the Green Bay and De Pere area. The pretest provided valuable feedback to the research team regarding where and why the survey instrument worked or didn’t work. Findings from the pretest suggested that the instruments developed served as a good starting point for a workable survey. However, more resources and time would be needed to address the issues identified during the pretest. Also, the time and resources required to successfully campaign this

survey and to collect enough data for meaningful statistical analysis would be beyond what this project could afford.

Instead of further pursuing the mail-out mail-back survey, the research team utilized the remaining resources to design and conduct a telephone survey of manufacturers. The intent of this telephone survey was to collect data to help verify the quality of the trip generation component of the NE Model and to shed light on how trip generation models could be improved in general. In particular, the survey questions were designed to better understand the *dynamics* or fluctuations in trip generation pattern. This is because past freight models have all been designed to represent freight movement on a “typical” weekday. However, our face-to-face interviews and paper-based survey pretest revealed that companies do not necessarily ship or receive on a regular basis. Calls were made to all the manufacturers on the InfoUSA listing that were located in the Brown County area. The response rate of around 8% was comparable to past paper-based surveys of freight stakeholders with multiple reminders. The response rate was lower than several past freight-related telephone surveys but higher than some internet based surveys.

While the sample data collected from the telephone survey was deemed too small in size to support meaningful multivariate statistical analysis (such as linear regression), our univariate and bivariate analysis of the data did lend support to our postulation that shipping activities could vary significantly from day to day. For example, the difference in trips generated between the most recent shipping day and last year’s busiest day was a 1400% difference for one of the participating manufacturers. This observation points to the need for further investigation into the extent of freight demand fluctuation across different times of the year. It also suggests the need to consider modeling tools capable of supporting “worst-scenario” analysis.

## REFERENCES

- Aissaoui, N., Haouari, M., Hassini, E., 2007. Supplier selection and order lot sizing modeling: a review. *Computers & Operations Research* 34(12), pp. 3516-3540.
- Andel, T., 1996. Manage inventory, own Information. *Transportation & Distribution* 37(5), pp. 54.
- Arunotayanun, K., Polak, J.W., 2010. Accommodating supply chain structure in models of freight mode choice. CD Proceedings-89th Annual Meeting of the Transportation Research Board, Washington, D.C., 10-14 January, 2010.
- Ballou, R.H., Srivastava, S.K., 2007. *Business Logistics/Supply Chain Management*. 5th edition, Pearson and Prentice Hall, pp. 574.
- Bartiz, S.G., Zissman, L., 1983. Researching customer service: the right way. *Proceedings of the National Council of Physical Distribution Management* 2, New Orleans, 25 October, 1983, pp. 608-619.
- Benton, W.C., 2007. *Purchasing and Supply Management*. McGraw-Hill Irwin, New York, NY, pp. 12-14.
- Berman, O., Krass, D., 2002. Locating multiple competitive facilities: spatial interaction models with variable expenditures. *Annals of Operations Research* 111(1-4), pp. 197-225.
- Bhatnagar, R., Chandra, P., Goyal, S.K., 1993. Models for multi-plant coordination. *European Journal of Operational Research* 67(2), pp. 141-160.
- Boerkamps, J.H.K., van Binsbergen, A.J., Bovy, P.H.L., 2000. Modeling behavioral aspects of urban freight movement in supply chains. *Transportation Research Record: Journal of the Transportation Research Board* 1725, pp. 17-24.
- Cavalcante, C., Roorda, M.J., 2010. A disaggregate urban shipment size/vehicle-type choice model. CD Proceedings-89th Annual Meeting of the Transportation Research Board, Washington, D.C., 10-14 January, 2010.
- Cetinkaya, S., Lee, C-Y., 2000. Stock replenishment and shipment scheduling for vendor-managed inventory systems. *Management Science* 46(2), pp. 217-232.
- Coase, R.H., 1937. The nature of the firm. *Economica* 4(16), pp. 386-405.
- Corey, E.R., 1978. Should companies centralize procurement? *Harvard Business Review* 56(6), pp. 102-110.
- de Jong, G., Ben-Akiva, M., 2007. A micro-simulation model of shipment size and transport chain choice. *Transportation Research Part B: Methodological* 41(9), pp. 950-965.

- Evers, P.T., Harper, D.V., Needham, P.M., 1996. The determinants of shipper perceptions of modes. *Transportation Journal* 36(2), pp. 13-25.
- Fischer, M.J., Outwater, M.L., Cheng, L.L., Ahanotu, D.N., Calix, R., 2005. Innovative framework for modeling freight transportation in Los Angeles County, California. *Transportation Research Record: Journal of the Transportation Research Board* 1906, pp. 105-112.
- Gill, L.E., Isoma, G., Sutherland, J.L., 1985. Inventory and physical distribution management. In Robeson, J. E., House, R.G. (Eds.), *The Distribution Handbook*, The Free Press, New York, NY, pp. 673.
- Guo, J.Y., Bhat, C.R., 2007. Population synthesis for microsimulating travel behavior. *Transportation Research Record: Journal of the Transportation Research Board* 2014, pp. 92-101.
- Harris, F.W., 1913. How many parts to make at once. *Factory*, *The Magazine of Management* 10(2), pp. 135-136.
- Hensher, D.A., Puckett, S.M., 2005. Refocusing the modelling of freight distribution: development of an economic-based framework to evaluate supply chain behaviour in response to congestion charging. *Transportation* 32(6), pp. 573-602.
- Heskett, J.L., 1994. Controlling customer logistics service. *International Journal of Physical Distribution & Logistics Management* 24(4), pp. 4.
- Hitchcock, F.L., 1941. The distribution of a product from several sources to numerous localities. *Journal of Mathematics and Physics* 20, pp. 224-230.
- Ho, W., Xu, X., Dey, P.K., 2010. Multi-criteria decision making approaches for supplier evaluation and selection: a literature review. *European Journal of Operational Research* 202(1), pp. 16-24.
- Hortacsu, A., Syverson, C., 2009. Why do firms own production chains? US Census Bureau Center for Economic Studies Paper No. CES 09-31. <http://ssrn.com/abstract=1484921>, Accessed July 10, 2010.
- Hunt, J.D., Stefan, K.J., 2007. Tour-based microsimulation of urban commercial movements. *Transportation Research Part B: Methodological* 41(9), pp. 981-1013.
- Jones, P.M., Koppelman, F.S., Orfeuil, J.P., 1990. Activity analysis: state of the art and future directions. In Jones, P. (Ed.), *Developments in Dynamic and Activity-Based Approaches to Travel Analysis*, Gower, Aldershot, England, pp. 34-55.
- Khouja, M., Goyal, S., 2008. A review of the joint replenishment problem literature: 1989-2005. *European Journal of Operational Research* 186, pp. 1-16.



- Kopczak, L.R. Johnson, M.E., 2003. The supply-chain management effect. *MIT Sloan Management Review* 44(3), pp. 27-34.
- Leeders, M.R., Fearon, H.E., Flynn, A., 2001. *Purchasing and Supply Management*. 12th edition, Homewood, IL: Irwin.
- Liedtke, G., 2009. Principles of micro-behavior commodity transport modeling. *Transportation Research Part E: Logistics and Transportation Review* 45(5), pp. 795-809.
- Maritan, C.A., Brush, T.H., Karnani, A.G., 2004. Plant roles of decision autonomy in multinational plant networks. *Journal of Operations Management* 22, pp. 489-503.
- McFadden, D., Winston, C., Boersh-Supan, A., 1986. Joint estimation of freight transportation decisions under nonrandom sampling. In Daugherty, A.F. (Ed.), *Analytic Studies in Transport Economics*, Cambridge University Press, pp. 135-157.
- McGinnis, M.A., 1990. The relative importance of cost and service in freight transportation choice: before and after deregulation. *Transportation Journal* 30(1), pp. 12-19.
- McMillen, D.P., 1992. Probit with spatial autocorrelation. *Journal of Regional Science* 32(3), pp. 335-348.
- Nguyen, Y.C., Sano, K., 2010. Location choice model for logistic firms with consideration of spatial effects. CD Proceedings-89th Annual Meeting of the Transportation Research Board, Washington, D.C., 10-14 January, 2010.
- Oboulhas, T., Xu, X., Zhan, D., 2005. Multi-plant purchase co-ordination based on multi-agent system in an ATO environment. *Journal of Manufacturing Technology Management* 16(6), pp. 654-669.
- Owen, S.H., Daskin, M.S., 1998. Strategic facility location: a review. *European Journal of Operational Research* 111(3), pp. 423-447.
- Qureshi, M.N., Kumar, D., Kumar, P., 2007. Modeling the logistics outsourcing relationship variables to enhance shippers' productivity and competitiveness in logistical supply chain. *International Journal of Productivity and Performance Management* 56(8), pp. 689-714.
- Razzaque, M.A., 1998. Outsourcing of logistics functions: a literature survey. *International Journal of Physical Distribution & Logistics Management* 28(2), pp. 89-107.
- Roorda, M.J., Cavalcante, R., McCabe, S., Kwan, H., 2010. A conceptual framework for agent-based modelling of logistics services. *Transportation Research Part E: Logistics and Transportation Review* 46(1), pp. 18-31.
- Samimi, A., Mohammadian, A., Kawamura, K., 2010. A behavioral freight movement microsimulation model: method and data. *Transportation Letters: The International Journal of Transportation Research* 2(1), pp. 53-62.

Schmenner, R.W., 1979. Look beyond the obvious in plant location. *Harvard Business Review* 57(1), pp. 126-132.

Shankar, V.N., Pendyala, R.M., 2001. Freight travel demand modelling: econometric issues in multi-level approaches. In Hensher, D. (Ed.), *The Leading Edge of Travel Behaviour Research*, Elsevier Science Publishers, B.V., The Netherlands, Chapter 38, pp. 629-644.

Statistics of U.S. Businesses (SUSB), 2007. U.S. Census Bureau <http://www.sba.gov/advo/research/data.html#us>. Accessed July 2, 2010

Stevenson, W., 2008. *Operations Management*. 10th edition, McGraw-Hill Irwin, New York, NY.

Theodore, P., Goldsby, T.F., 2000. A framework for transportation decision making in an integrated supply chain. *Supply Chain Management: An International Journal* 5(2), pp. 71-77.

Walker, G., Weber, D., 1984. A transaction cost approach to make-or-buy decisions. *Administrative Science Quarterly* 29(3), pp. 373-391.

Wisetjindawat, W., Sano, K., Matsumoto, S., Raathanachonkun, P., 2007. Microsimulation model for modeling freight agents interactions in urban freight movement. CD Proceedings-86th Annual Meeting of the Transportation Research Board, Washington, D.C., 21-25 January, 2007.

Wisner, J.D., Leong, G.K., Tan, K-C., 2005. *Principles of Supply Chain Management: A Balanced Approach*. Thomson South-Western, Mason, OH, pp. 49-51.

Yang, C.H., Chow, J.Y.J., Regan, A.C., 2009, State of the Art of Freight Forecasting Modeling: Lessons Learned and the Road Ahead, CD Proceedings-88th Annual Meeting of the Transportation Research Board, Washington, D.C., 11-15 January, 2009.

# APPENDIX A. Firm-Based Survey Instrument

## Cover Letter



### University of Wisconsin-Madison Business Establishment Survey



Dear Participant,

Per your telephone conversation with Libby Ogard last week, thank you for agreeing to participate in this Business Establishment Survey. This survey is administered by the Transportation and Urban Systems Analysis (TUSA) Laboratory at the University of Wisconsin-Madison as part of a research project to study the decision-making processes leading up to the freight transportation pattern in the Northeast WI region.

#### ***How may the study benefit you?***

This research study is supported by the East Central Wisconsin Regional Planning Commission (ECWRPC), Wisconsin Department of Transportation (WisDOT) and National Center for Freight and Infrastructure Research and Education (CFIRE). Ultimately, it is expected to help ECWRPC and WisDOT make sound decisions regarding freight infrastructure investment and policies. By participating in this survey:

- Your transportation needs will be better understood and served with a more efficient transportation system.
- You will receive our study results to enhance your awareness of the freight community in the region.

#### ***What do you need to do?***

The following materials have been included in this survey packet:

- A. 1 x Establishment Survey Questionnaire – Please complete by March 14<sup>th</sup>.
- B. 1 x List of Establishment(s) in Wisconsin – Please complete by March 14<sup>th</sup>.
- C. 5 x Truck Diary – Please distribute the diaries to 5 of your truck drivers on duty on March 1<sup>th</sup> and have them return the completed diaries to you at the end of their shift.
- D. 1 x Survey Feedback Questionnaire – Please complete after you have finished items A, B and C.
- E. 1 x Supplementary Material: Transportation Mode Code (yellow sheet) – for filling out item A.
- F. 1 x Supplementary Material: NAICS Industry Code (green sheet) – for filling our items A and B.

Libby Ogard will collect items A, B, C and D when she visits with you. I ask that you please respond to the survey questions to the best of your ability and in as much detail as possible. Rest assured that all data you provide will remain confidential and will not be shared with anyone outside of the research team. Only analysis results in an aggregated format (e.g. percentage distributions and regional averages) would subsequently be reported in research publications and be made available to the study participants. If you have any questions about the survey, please do not hesitate to contact me at (608) 890-1064.

Once again, thank you for agreeing to participate in this survey. Your response will be valuable in helping improve freight transportation efficiency in Wisconsin.

Sincerely,

Professor Jessica Y. Guo  
Director of Transportation and Urban Systems Analysis Laboratory  
University of Wisconsin-Madison



**ESTABLISHMENT SURVEY QUESTIONNAIRE**

**Section 1: Firm History and Assets**

- A. In which year was your firm first established? \_\_\_\_\_
- B. Does your firm own or lease a fleet of trucks?  Own  Lease  Does not own or lease trucks

If your firm owns or leases trucks, how many of the following truck types are there?  
PLEASE refer to the attached *YELLOW* sheet for truck type illustrations.

- 1. Straight truck \_\_\_\_\_
- 2. Truck plus trailer \_\_\_\_\_
- 3. Tractor semitrailer \_\_\_\_\_
- 4. Tractor doubles \_\_\_\_\_
- 5. Tractor-triple trailers \_\_\_\_\_
- 6. Other truck type \_\_\_\_\_

**Section 2: Firm Structure**

A. Please refer to the attachment titled *LIST OF ESTABLISHMENT(S) IN WISCONSIN*, which lists establishments/sites of your firm in Wisconsin that conduct business in the agriculture, mining, manufacturing or wholesale trade industries. Please verify the information and make any corrections as necessary.

- B. Does your firm contract any warehouse or distribution center in Wisconsin to store and/or distribute goods?  
 Yes  No

If yes, please list below all contracted warehouses/distribution centers in Wisconsin.  
PLEASE use the establishment reference number on *LIST OF ESTABLISHMENT(S) IN WISCONSIN* (per A above) to fill in the "Establishments served by this warehouse/distribution center" column.

Ref. Number	City/Town	State	ZIP code	Square footage rented	Annual amount of goods shipped from this warehouse (in tons)	Establishments served by this warehouse/distribution center
W1						
W2						
W3						
W4						
W5						

## ESTABLISHMENT SURVEY QUESTIONNAIRE

**Section 3: Establishment History and Assets**

- A. In which year did your firm begin operation at this location? \_\_\_\_\_
- B. How many full time employees are at this location? \_\_\_\_\_
- C. What are the annual sales for your firm at this location? \$ \_\_\_\_\_
- D. What primary industry does your firm operate at this location?  
PLEASE use the NAICS industry code provided on the attached *GREEN* sheet.  
Industry: \_\_\_\_\_

**Section 4: Inbound Commodity**

- A. What is the total weight of annual inbound commodities received at this location? \_\_\_\_\_ tons
- B. Do you charge your suppliers a penalty for early/late delivery (check all that apply)? If you do, please specify the penalty structure (for example, charge \$100 if order is delivered 2 hours late).
- Early Delivery, penalty structure: \_\_\_\_\_
- Late Delivery, penalty structure: \_\_\_\_\_
- No penalty charges imposed
- C. On the next three pages, please identify the TOP THREE industries from which you acquire inbound commodities.  
For EACH industry, please list your TOP THREE suppliers, ranked by annual weight of commodities from each supplier.  
PLEASE NOTE:
- Use the industry classification code on the attached *GREEN* sheet in the "Industry code" box.
  - Keep in mind that a supplier may be another establishment/division within your firm.
  - If the supplier is in a foreign country, please indicate the country name in the "Supplier name" column and identify the "County, State and ZIP code" of the port or gateway from which the freight enters the U.S.
  - "Lead time" refers to the amount of time between the placing of an order and the receipt of the order

ESTABLISHMENT SURVEY QUESTIONNAIRE

**Section 4: Inbound Commodity (cont.)**

<b>FIRST Industry</b> as major source of inbound commodity	Industry code
1. Annual inbound commodities from this industry: weight _____ tons, value \$ _____ 2. Split of annual inbound commodity (in weight) by season: Mar-May _____% Jun-Aug _____% Sept-Nov _____% Dec-Feb _____% 3. Average number of days of inventory kept on-site: _____ 4. Number of regular suppliers in this industry that you use: _____ 5. Typical time of the day and day(s) of the week when you receive shipments from this industry: ____ : ____ am/pm – ____ : ____ am/pm <input type="checkbox"/> Mon <input type="checkbox"/> Tue <input type="checkbox"/> Wed <input type="checkbox"/> Thu <input type="checkbox"/> Fri <input type="checkbox"/> Sat <input type="checkbox"/> Sun (check all that apply)	

**FIRST major supplier**

Supplier name		Supplier location			Shipment frequency
		City/Town	State	ZIP code	
A typical order/shipment from this supplier					
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	

**SECOND major supplier**

Supplier name		Supplier location			Shipment frequency
		City/Town	State	ZIP code	
A typical order/shipment from this supplier					
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	

**THIRD major supplier**

Supplier name		Supplier location			Shipment frequency
		City/Town	State	ZIP code	
A typical order/shipment from this supplier					
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	

ESTABLISHMENT SURVEY QUESTIONNAIRE

**Section 4: Inbound Commodity (cont.)**

**SECOND** Industry as major source of inbound commodity

Industry code

- Annual inbound commodities from this industry: weight \_\_\_\_\_ tons, value \$ \_\_\_\_\_
- Split of annual inbound commodity (in weight) by season:  
 Mar-May \_\_\_\_\_% Jun-Aug \_\_\_\_\_% Sept-Nov \_\_\_\_\_% Dec-Feb \_\_\_\_\_%
- Average number of days of inventory kept on-site: \_\_\_\_\_
- Number of regular suppliers in this industry that you use: \_\_\_\_\_
- Typical time of the day and day(s) of the week when you receive shipments from this industry:  
 \_\_\_\_:\_\_\_\_ am/pm – \_\_\_\_:\_\_\_\_ am/pm  Mon  Tue  Wed  Thu  Fri  Sat  Sun (check all that apply)

**FIRST major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?	Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

**SECOND major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?	Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

**THIRD major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?	Order filled by your warehouse/distribution center?	
		<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

ESTABLISHMENT SURVEY QUESTIONNAIRE

**Section 4: Inbound Commodity (cont.)**

THIRD Industry as major source of inbound commodity

Industry code

- Annual inbound commodities from this industry: weight \_\_\_\_\_ tons, value \$ \_\_\_\_\_
- Split of annual inbound commodity (in weight) by season:  
 Mar-May \_\_\_\_\_% Jun-Aug \_\_\_\_\_% Sept-Nov \_\_\_\_\_% Dec-Feb \_\_\_\_\_%
- Average number of days of inventory kept on-site: \_\_\_\_\_
- Number of regular suppliers in this industry that you use: \_\_\_\_\_
- Typical time of the day and day(s) of the week when you receive shipments from this industry:  
 \_\_\_\_:\_\_\_\_ am/pm – \_\_\_\_:\_\_\_\_ am/pm  Mon  Tue  Wed  Thu  Fri  Sat  Sun (check all that apply)

**FIRST major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No

**SECOND major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No

**THIRD major supplier**

Supplier name	Supplier location			Shipment frequency
	City/Town	State	ZIP code	
A typical order/shipment from this supplier				
Quantity (in tons)	Lead time (in days)	Order placed jointly with other establishments in your firm?		Order filled by your warehouse/distribution center?
		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No



**ESTABLISHMENT SURVEY QUESTIONNAIRE**

**Section 5: Outbound Commodity**

A. What is the total weight (in tons) of annual outbound commodities shipped from this location? \_\_\_\_\_ tons

B. What is the split (in weight) of annual outbound commodities by season:

Mar-May \_\_\_\_\_% Jun-Aug \_\_\_\_\_% Sept-Nov \_\_\_\_\_% Dec-Feb \_\_\_\_\_%

C. Do you store the outbound commodities at another location (e.g., a warehouse) before they are shipped out?

Yes  No

If yes, please specify the location where you store the outbound commodities. If this is a location already identified in the *LIST OF ESTABLISHMENT(S) IN WISCONSIN* or in your response to SECTION 2B, please use the corresponding reference number. Otherwise, please provide the street address of this location.

\_\_\_\_\_

D. How many customers (including the other establishments within your firm) do you regularly ship commodities to?

\_\_\_\_\_

E. In the table below, please provide information about your TOP FIVE major customers for this location in the order of annual weight of commodities shipped to each customer.

PLEASE NOTE:

- Keep in mind that a customer may be another establishment/division within your firm. If you choose not to disclose the customer's name, please specify the customer's industry type instead using the industry code on the *GREEN* sheet.
- If the customer is in a foreign country, please indicate the country name in the "Customer name" column and identify the "County, State and ZIP code" of the port or gateway from which the freight exits the U.S.
- "Lead time" refers to the amount of time between the customer placing and receiving an order.

Ref. number	Customer name	Customer location			Annual outbound commodity shipped to this customer		A typical shipment to this customer	
		County	State	ZIP code	Total weight (in tons)	Total value (in \$1,000)	Total weight (in tons)	Lead Time (in days)
C1								
C2								
C3								
C4								
C5								

ESTABLISHMENT SURVEY QUESTIONNAIRE

**Section 5: Outbound Commodity (cont.)**

F. In the table below, please describe how a TYPICAL shipment is delivered to EACH of the customers (as identified by the corresponding Ref. Number) listed in SECTION 5E.

PLEASE NOTE:

- If a contracted carrier or a third party logistics (3PL) service provider is used for shipping, please identify its name if possible.
- In the "Transportation mode used" column, use the codes listed on the attached *YELLOW* sheet. If the commodity is moved from one truck to another, it is considered as a mode change.
- Identify all the modes used and the corresponding locations of mode change in the order that they are used, starting from when the shipment leaves your location and until it ends up at the customer's location (or the port/gateway of exit).

Ref. Number	Primary transportation service provider	Order of mode used	Transportation mode used	Location of mode change (ZIP code)
C1	<input type="checkbox"/> Organized by customer	1		
	<input type="checkbox"/> Private (owned or rented) fleet	2		
	<input type="checkbox"/> Contracted carrier: _____ <input type="checkbox"/> 3PL service provider: _____	3		
C2	<input type="checkbox"/> Organized by customer	1		
	<input type="checkbox"/> Private (owned or rented) fleet	2		
	<input type="checkbox"/> Contracted carrier: _____ <input type="checkbox"/> 3PL service provider: _____	3		
C3	<input type="checkbox"/> Organized by customer	1		
	<input type="checkbox"/> Private (owned or rented) fleet	2		
	<input type="checkbox"/> Contracted carrier: _____ <input type="checkbox"/> 3PL service provider: _____	3		
C4	<input type="checkbox"/> Organized by customer	1		
	<input type="checkbox"/> Private (owned or rented) fleet	2		
	<input type="checkbox"/> Contracted carrier: _____ <input type="checkbox"/> 3PL service provider: _____	3		
C5	<input type="checkbox"/> Organized by customer	1		
	<input type="checkbox"/> Private (owned or rented) fleet	2		
	<input type="checkbox"/> Contracted carrier: _____ <input type="checkbox"/> 3PL service provider: _____	3		

# List of Establishments in Wisconsin

ME-001-ES(PST)

## LIST OF ESTABLISHMENT(S) IN WISCONSIN

The table below lists every establishment/site of your firm (Shopko Stores Inc.) that is located in Wisconsin and operates primarily in one of the following industries:

- Agriculture, Forestry, Fishing and Hunting
- Mining, Quarrying, and Oil and Gas Extraction
- Manufacturing
- Wholesale trade

PLEASE verify the information summarized in the table and make any corrections as necessary.

- If the establishment does not exist or is closed, strike through the entire line.
- If there is incorrect information about the establishment, please make corrections in the corresponding cell.
- If any of your Wisconsin establishments (per categories listed above) are missing from the list below, please enter them in the space provided at the bottom of the table.
- In the "Primary business" column, please use the industry classification and codes provided on the attached *GREEN* sheet.

Ref. number	Street address	City / town / village	Zip code	Primary business (NAICS code)	Number of employees	Annual sales amount	Square footage
E1	1717 Lawrence Dr	De Pere	54115	Merchant Wholesalers, Nondurable Goods (424)	250	\$179,500,000	40,000+
Additional Establishment(s):							
E2							
E3							
E4							
E5							
E6							



## TRUCK DIARY

### STOP 3

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

\_\_\_\_\_

Street Address

\_\_\_\_\_

City/Town

State

\_\_\_\_\_

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

### STOP 4

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

\_\_\_\_\_

Street Address

\_\_\_\_\_

City/Town

State

\_\_\_\_\_

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

### STOP 5

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

\_\_\_\_\_

Street Address

\_\_\_\_\_

City/Town

State

\_\_\_\_\_

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

### STOP 6

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

\_\_\_\_\_

Street Address

\_\_\_\_\_

City/Town

State

\_\_\_\_\_

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

## TRUCK DIARY

**STOP 7**

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

Street Address

City/Town State

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

**STOP 8**

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

Street Address

City/Town State

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

**STOP 9**

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

Street Address

City/Town State

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

**STOP 10**

Arrival Time: \_\_\_:\_\_\_ am/pm

Departure Time: \_\_\_:\_\_\_ am/pm

Company or Location Name:

Street Address

City/Town State

Activities Performed at This Location (check all that apply)

- Pickup goods – weight of goods loaded: \_\_\_\_\_ tons
- Deliver goods – weight of goods delivered: \_\_\_\_\_ tons
- Deliver service
- Stop for fueling
- Stop for vehicle weighing
- Stop to rest
- Other, please specify: \_\_\_\_\_

## Transportation Mode Code

### SUPPLEMENTARY MATERIAL: TRANSPORTATION MODE CODES

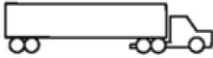
1- Straight truck



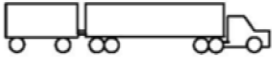
2- Truck plus trailer



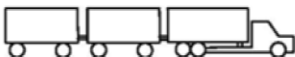
3- Tractor semitrailer



4- Tractor doubles



5- Tractor-triple trailers



6- Other truck

7- Railroad

8- Shallow draft vessel

9- Deep draft vessel

10- Pipeline

11- Air

12- Other mode

## Industry Code

### SUPPLEMENTARY MATERIAL: NAICS INDUSTRY CODES

#### Agriculture, Forestry, Fishing and Hunting

- 111- Crop Production
- 112- Animal Production
- 113- Forestry and Logging
- 114- Fishing, Hunting and Trapping
- 115- Support Activities for Agriculture and Forestry

#### Mining, Quarrying, and Oil and Gas Extraction

- 211- Oil and Gas Extraction
- 212- Mining (except Oil and Gas)
- 213- Support Activities for Mining

#### Manufacturing

- 311- Food Manufacturing
- 312- Beverage and Tobacco Product Manufacturing
- 313- Textile Mills
- 314- Textile Product Mills
- 315- Apparel Manufacturing
- 316- Leather and Allied Product Manufacturing
- 321- Wood Product Manufacturing
- 322- Paper Manufacturing
- 323- Printing and Related Support Activities
- 324- Petroleum and Coal Products Manufacturing
- 325- Chemical Manufacturing
- 326- Plastics and Rubber Products Manufacturing
- 327- Nonmetallic Mineral Product Manufacturing
- 331- Primary Metal Manufacturing
- 332- Fabricated Metal Product Manufacturing
- 333- Machinery Manufacturing
- 334- Computer and Electronic Product Manufacturing
- 335- Electrical Equipment, Appliance, and Component Manufacturing
- 336- Transportation Equipment Manufacturing
- 337- Furniture and Related Product Manufacturing
- 339- Miscellaneous Manufacturing

#### Wholesale Trade

- 423- Merchant Wholesalers, Durable Goods
- 424- Merchant Wholesalers, Nondurable Goods
- 425- Wholesale Electronic Markets and Agents and Brokers



## Survey Feedback

**Below is a list of questions about your experience in filling out the UW Business Establishment Survey. The information you provide will be very valuable in helping us further improve the survey materials. Thank you for your feedback!**

1. How long did it take to complete the ESTABLISHMENT SURVEY QUESTIONNAIRE (excluding the truck diaries)?

\_\_\_\_\_ minutes

2. How would you rate the ease of understanding the questions in each of the following sections of the ESTABLISHMENT SURVEY QUESTIONNAIRE?

		Very Easy	Easy	Neutral	Difficult	Very Difficult
Section 1.	Firm History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 2.	Firm Structure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 3.	Establishment History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 4.	Inbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 5.	Outbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. How would you rate the ease in providing information to the questions in each of the following sections of the ESTABLISHMENT SURVEY QUESTIONNAIRE?

		Very Easy	Easy	Neutral	Difficult	Very Difficult
Section 1.	Firm History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 2.	Firm Structure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 3.	Establishment History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 4.	Inbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 5.	Outbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. How would you rate the sensitivity of the information collected in each of the following sections of the ESTABLISHMENT SURVEY QUESTIONNAIRE?

		Not At All Sensitive	Non-Sensitive	Neutral	Sensitive	Highly Sensitive
Section 1.	Firm History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 2.	Firm Structure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 3.	Establishment History and Assets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 4.	Inbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Section 5.	Outbound Commodity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. How would you rate the ease of using the following supplementary material when filling out the ESTABLISHMENT SURVEY QUESTIONNAIRE?

	Very Easy	Easy	Neutral	Difficult	Very Difficult
TRANSPORTATION MODE CODES (Orange Sheet)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
NAICS INDUSTRY CODES (Green Sheet)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Were any staff members other than yourself involved in filling out the ESTABLISHMENT SURVEY QUESTIONNAIRE?

Yes       No

If yes, please list the job titles of these staff members and describe how the questions were split among them.

7. How would you rate the ease of administering the TRUCK DIARY with your truck drivers?

Very Easy	Easy	Neutral	Difficult	Very Difficult
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

8. In what way would you have preferred to receive and complete this survey?

- As a MS Word document via email  
 As a paper-based mail-out mail-back survey  
 As an on-line interactive survey  
 Other, please specify: \_\_\_\_\_



## SHIPPING ACTIVITY SURVEY



Dear Participant,

This survey is administered by TUSA LAB at the University of Wisconsin-Madison as part of a research project to study the freight transportation pattern in the Northeast WI region. The study is intended to help the East Central Wisconsin Regional Planning Commission and Wisconsin Department of Transportation make sound investment decisions to better serve businesses' transportation needs. Any information that you provide will be held in the strictest confidence and will be aggregated for reporting purposes only. If you have any questions or concerns regarding this survey, please don't hesitate to contact TUSA Lab Director, Dr Jessica Guo, at 512-771-4663.

Thanks very much for your help!

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The following questions are concerned with your company's primary manufacturing facility in Brown County, Wisconsin.

Q1. Where is your company's primary manufacturing facility in Brown County, Wisconsin?  
Please provide the address.

Q2. In which year did your company begin operation at this facility?

Q3. What do you manufacture at this facility?

Q4. What is the total square footage of this facility?

Q5. Whom do your products go directly to? Please select all that apply.

- Manufacturers
- Wholesalers
- Retailers
- Households

- Manufacturing facilities within your company
- wholesalers within your company
- Retail stores within your company
- Other -> Please explain:



## SHIPPING ACTIVITY SURVEY



Q6. Where are most of your customers located?

- In Brown County
- In certain parts of Wisconsin -> Which part of the State?
- All throughout Wisconsin
- Across the U.S. -> Any particular part of the country?
- Overseas -> Any particular countries?

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The next few questions are about your manufacturing facility's outbound shipments. By "an outbound shipment" we mean a movement of commodities from your facility to another location.

Q7. How often do you have outbound shipments leaving the facility?

- Daily
- Weekly -> On any particular days of the week?
- Monthly -> On any particular days of the month?
- A few times a year -> During any particular months?
- Less than yearly
- Never

Q8. Who provides the transportation service to pick up outbound shipments from your manufacturing facility? Please select all that apply.

- Your own fleet
- Your rented fleet
- Your contracted carriers
- 3 PL service providers
- Your customers
- Other -> Please explain:



## SHIPPING ACTIVITY SURVEY



Q9. What type of carrier service do you typically use to ship your goods? Please select all that apply.

- Truckload
- Less Than Truckload (LTL)
- Parcel
- Other / Do not apply

Q10. In what type of vehicles do shipments typically leave your facility?

- Trucks
- Commercial vehicles
- Personal vehicles
- Other -> Please specify:

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The next few questions are related to the frequency of shipping trips departing from your manufacturing facility. By a "shipping trip" we mean an instance of a vehicle leaving your facility to deliver outbound shipments.

Q11. What was the total number of outbound vehicle trips made out of your facility during the past 7 days?

Q12. When was the last day (before today) that you had any outbound shipment? Please provide the date in mm/dd/yy format.

Q13. On the day when you last had outbound shipments, what was the total number of outbound shipping trips made out of your facility?

Q14. On the day when you last had outbound shipments, what the total weight and value of the shipments?

Total weight:

Total dollar value:



## SHIPPING ACTIVITY SURVEY



Q15. On your busiest day in year 2011:

a. How many outbound shipping trips did you have at this manufacturing facility?

b. What month of the year was that?

Q16. In your estimate, what was the total weight and value of products shipped out of this manufacturing facility in year 2011?

Total weight:

Total dollar value:

Q17. Typically what modes of transportation are involved to get your outbound shipments from your manufacturing facility to the customers? Please select all that apply.

Trucks or other vehicles

Rail

Water

Air

Other -> Please specify:

Q18. Under what circumstances would you consider using the rail or water modes for your outbound shipping?

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**Thank you for participating in this survey!**



**CFIRE**

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