Comprehensive Truck Size and Weight (TS&W) Study

Phase 1-Synthesis

Logistics

and

Truck Size and Weight Regulations

Working Paper 8

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This paper: (1) describes current logistics practices as they are affected by truck size and weight limits; (2) examines how changes in truck size and weight limits might affect logistics practices; and (3) where possible, identifies research needed to close knowledge gaps regarding truck size and weight limits and how they affect logistics practices. This paper will focus on the shippers' perspectives.

1.0 Technical Relationships of Policy Consequences Concerning Logistics

To date, logistics research that incorporates transportation costs has focused mainly on optimizing shipment quantities with respect to inventory carrying costs and transportation costs through the use of economic order quantity (EOQ) models. These models typically include product value, product demand, inventory carrying charges, transit times and shipment sizes in their analyses.

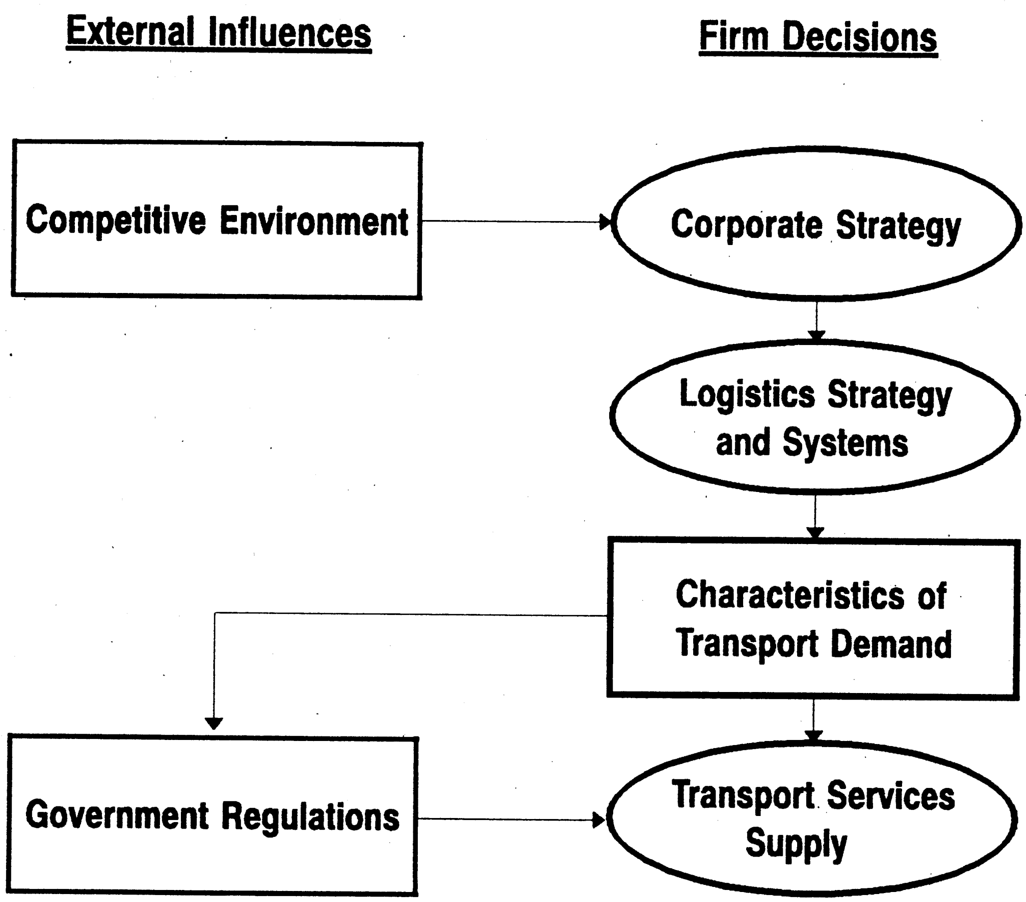
To properly analyze from a shipper's perspective the logistics decisions as they are impacted by truck size and weight regulations, it is necessary to put these decisions in context. As Figure 1 indicates, firms develop corporate strategies in response to their assessment of the current and future competitive environment. These strategies define the products/services the firm will produce, the geographic markets the firm will compete in, the approaches to product design and pricing the firm will follow, etc. Operating components, such as manufacturing, information, and logistics strategies and systems, are then designed to be consistent with the overall corporate strategy. The logistics strategies and systems define the character of demand for logistics and transportation services. Character of demand includes shipment frequencies, regularity, size of shipment, time and reliability requirements, special handling, climate control, etc. These characteristics of demand are the customer expectations that transport service suppliers must respond to in the design and provision of their systems and services, given government regulations such as vehicle size and weight limitations.

1.1 Competitive Environment

While there are many factors both positively and negatively affecting shipper's demand for road-based transportation, these can be aggregated into the issues of globalization, scope, and the distribution of market leverage.

Figure 1.

Conceptual Model of Decision-Structure Linkages from Competitive Environment to Transport Supply



(a) Globalization

As a trend the world continues to evolve into a series of trading blocs, with the European Union and North American Free Trade Agreement (NAFTA) being the most notable. Opportunities exist for expansion of their membership as well as the potential for additional blocs to develop in areas such as the Pacific Rim and South America.

The passage of the General Agreement on Tariffs and Trade will further liberalize international trade which is currently estimated to be growing at a rate 2.5 to 3.0 times that of U.S. gross domestic product. Growth in trade of higher value-added goods is expected to outpace trade growth of bulk raw materials. While Canada and Mexico as a bloc will continue as the most significant U.S. trading partners, continuing growth in trade with other partners suggests that ocean container traffic will grow and will be borne at least in part by the highway system.

Opportunities for dramatically increasing the average container sizes of the worldwide fleet appear minimal. Dominated by 20- and 40-foot units, increases in physical size are constrained by 1) the costs of modifying the existing fleets of cellular container ships, a fleet which continues to see vessels built today using the 20-foot multiple as standard, and 2) physical limitations of existing foreign infrastructure. This latter point not only includes bridge and road surface capacities, but the tunnel and overpass clearances and turning radii found to exist among many of the significant trading partners. It is noted that some limited number of carriers, such as American President Lines, have been increasing their use of 45-, 48-, and 53-foot units, but can only employ these on limited trade routes.

Moreover, the use of containerization continues to expand in both international trade and domestic commerce. Research through simulation of various truck weight alternatives found that heavier U.S. domestic truck weight limits could encourage transloading of multiple marine containers into fewer dry vans in order to achieve economies when low-value, non-time-sensitive freight is involved (Rao and Young, 1992).

(b) National Versus Regional Scope

Both regional and national markets exist for both truckload (TL) and less-than-truckload (LTL) general commodity carriers. Transportation firms addressing other market segments fall into two broad categories: bulk movements and high-value/time-sensitive service requirements. The refrigerated services market will, for the purposes of this discussion, be categorized as general commodity carriers because of the flexibility of using their equipment for non-refrigerated cargoes.

Specialized carriers transporting various bulk commodities with equipment having limited or focused capabilities generally are regional carriers. Moving commodities such as polymers, aggregates, food ingredients, petroleum products, and steel, their regional character may be frequently defined by the presence of a rail component for longer-distance line-haul followed by transloading to bulk truck for ultimate delivery to consignees. For shorter distances within regions, movement tends to be all truck. The specific trip length where the shipment changes from an all truck movement to a combination of rail and truck will vary by commodity and the region of the country.

High-value and time-sensitive materials typically utilize general cargo equipment. The shipments tend to be served by carriers that can provide nationwide coverage. A notable exception may be those situations where "specialty messenger" services, such as those offered by Roberts Express (a unit of Roadway), are required. Time sensitive transportation, not so much related to the intrinsic value of the cargo as to the loss or deferral of its use, also focuses on an environment of minimal transit times with equipment utilization factors being either tertiary or non-existent issues.

(c) Distribution of Market Leverage

Deregulation brought a shift in the balance of power in U.S. shipper-carrier relationships whereby the market clearly began to favor shippers. Issues which have continued to influence this relationship include transportation technology innovation, the development of information technology and labor relations. Those carriers that excel in these matters and use them to provide differentiated service capabilities and quality will gain market leverage that will shift some market power back to these select carriers.

From a technology innovation perspective, one example is the development of air-ride suspensions which reduce incidences of loss and damage and consequently carrier payment of shipper claims. A second, improved vehicle aerodynamics, improves fuel efficiency which is a major variable cost to carriers.

The development of geographic positioning systems and transportation planning software enables the identification of inbound vehicles which can immediately be turned around for outbound shipments (i.e., backhauls) clearly enhances carrier productivity and service levels. However, if the technology is used by major shippers, rather than carriers, and the shippers then seek rate concessions on both transportation legs, such technology development creates further market leverage for the shippers.

The driver shortage stems in part from uncompetitive wages and negative life style attributes (e.g., minimal family time) of long-haul trucking (Richardson, 1994). These conditions may be partially offset, at least in the longer term, by fewer loads as a result of introducing larger vehicles and higher weight limits. In the shorter term, however, longer vehicles may compound the shortage given the increasing use of trailer-on-flatcar (TOFC) strategies for longer hauls. While flatcars capable of handling multiple 53-foot trailers are presently being introduced, most of this fleet was designed for shorter trailers. The consequence is less productive utilization of railcar capacity with the result being the return of many trailers to the highways for long distance moves. This phenomenon portends a repeat of the earlier experience when 45-foot trailers were introduced and the rail system endured the occurrence of "phantom 45s". (The loss of one platform space on a two-position trailer-on-flatcar railcar designed for two 40-foot trailers, when one space is occupied by a 45-foot trailer.)

1.2 Corporate Strategy

This section on corporate strategy is not meant to be a comprehensive treatment of alternative strategies in the classical typology of innovator, low-cost producer, etc. Rather this discussion focuses aspects of emerging strategies that directly influence logistics systems and the character of demand for freight transport. These aspects include a focus on customer requirements, an emphasis on speed in lead-time management, and re-engineering the supply-chain.

(a) Focus on Customer Requirements

There is little disagreement that customers, including both ultimate consumers and intermediate businesses, are becoming more demanding of not just of product quality, but also service quality. For product markets where there is little perceived technical difference in the quality of the product, service competition takes on added importance. Value added through service offerings is an increasingly important road to achieving competitive advantage. A logistics system that provides a firm sufficient flexibility to pursue new market opportunities, to meet the demand for speed, quick response and consistency in delivery, global reach, nimbleness or flexibility in meeting quickly changing customer requests - these capabilities add value to a firm's offerings.

In reality, the ability to become a world class supplier depends as much upon the effectiveness of our operating systems as it does upon the presentation of the product, the creation of images and the influencing of consumer perceptions. ... The success of companies like McDonald's, British Airways, or any of the other frequently cited paragons of service excellence (such as Wal-Mart, L.L. Bean, Compaq, Proctor & Gamble) is not due to their choice of advertising agency, but rather to their recognition that the logistics of service delivery on a consistent basis is the crucial source of differential advantage. (Christopher)

(b) Strategic Lead-Time Management

Business historians will record the middle and late 1980s as the dawning of the age of speed as a strategic focus for achieving competitive advantage. Fast, reliable, and flexible operations coupled with innovative information technologies that enable real-time learning and response are potent competitive weapons (Bower and Hout). Cutting-edge manufacturers such as Hewlett-Packard, Honda, Toyota, and Motorola, have a speed culture that does not permit time-consuming processes that unnecessarily add to costs and impede their organizations' abilities to respond in sufficient time to changing market opportunities (Dumaine). In many leading-edge organizations, time-based competitive strategies have taken center stage, replacing older, cost- or scale-based approaches (Stalk).

Time-based strategies take many forms. To increase the pace of change in product variety and achieve customer service excellence time-conscious manufacturers are shortening the planning loop in product development cycles, trimming process time in factories, and improving the speed and reliability of distribution networks (Stalk). At Hewlett-Packard, speed is the core of competitive strategy. Time reduction initiatives are focused on the goal set by CEO John Young to halve the breakeven time, the period from new product conception to profitability. Every operation, from product development through distribution, is involved in time reduction efforts (Dumaine).

Many manufacturers have gained speed superiority from implementing just-in-time (JIT) production systems and soft factories. (Through a combination of a heavy dose of information technology and a flexible mix of labor and automated machinery, soft or digital factories have the capability to produce an endless variety of products at mass-production speeds in quantities that can be as small as one (Bylinsky)). But the move to time-based competitive strategies is not limited to manufacturers. Companies in service, wholesale, retail and transportation sectors are also wielding time as a strategic weapon. Benetton, for example, electronically links retail outlets in 60 countries with their factory and distribution center in Italy to enable rapid within-season reorders, an anomaly in the slow world of retail manufacturing and distribution (Dumaine). The Limited, Federal Express, Domino's Pizza, and McDonald's are other retail and transportation time-based competitors (Stalk).

The growing emphasis on speed to achieve competitive advantage is changing the characteristics of demand for freight transportation services. For example, JIT or similar time-sensitive manufacturing planning and control systems favor smaller shipment quantities, more frequent shipments on shorter lead times, and more precise schedules than traditional scale-based production systems (Rao, et al). Surveys show quick response capabilities and near-perfect reliability to be the most significant of emerging customer expectations. Research by Lieb and Miller found that 90 percent of JIT users said carrier responsiveness to short-term needs and on-time performance are much more important than they had been prior to JIT implementation. Capability to determine shipment location (76 percent), extent of route network (56 percent), price (47 percent), carrier terminal proximity (44 percent), and availability of specialized equipment (35 percent) were also reported to be much more important according to the JIT users responding to the survey. (However, no implications of the change in the importance of these factors for size and weight of shipments is reported.) An unanswered question is the extent to which a change in the cost structure of transportation inputs brought about by more permissive truck size and weight policy might produce sufficient transport savings to induce shippers to make larger shipments despite the increase in inventory and warehousing costs. Some insight on this issue is gained from a study by Middendorf and Bronzini discussed in a later section of this paper.

(c) Supply-Chain or Throughput Management

Supply Chain Management (SCM) is the integrated approach to managing material and information flow among suppliers, carriers, manufacturers, distributors, and end-users with a focus on coordination to eliminate duplication and improve customer service. Supply chain management integrates the total network from raw material suppliers through the manufacturer, retailer, and ultimately, the customer. This approach eschews myopic management practices that focus only on performance of individual functions. SCM promotes integration of individual functions into a network or system whose performance is to be optimized.

Re-engineering the supply chain is being recognized for the potential cost savings that can be achieved. Van Waters and Rogers, the largest U.S. chemical distributor has noted that there is a greater opportunity for reducing cost in the supply chain, than in manufacturing. For example, moving a pallet into a warehouse, re-positioning it, storing it, and then moving it out again often adds little value to the product offering, but adds considerable cost. SCM means closer alliances among entities in the supply chain, including carriers. The Boston Consulting Group has observed that competition is no longer between firms, but between supply chains (Henkoff).

Important examples of how major U.S. firms have improved SCM can be found at GE Medical Systems (GEMS), K-Mart, an anonymous computer manufacturer, and Nabisco. To better manage its supply chain, reduce inventory costs, and improve service levels, GEMS has implemented a program called Integrated Supplier Program (ISP) as an approach to purchasing low-value materials, packaging, and maintenance, repair, and operating supplies. GEMS went from over 500 suppliers down to a core of six who coordinate all of the purchases from the other suppliers and distributors which GEMS formerly dealt with directly. The core manages inventory, conducts physical inventory counts, and places orders. GEMS is electronically linked with suppliers by electronic mail and electronic data interchange (EDI) for ordering, invoicing, payment, transferring forecast data, and bar coding of inventory items (Ellram, March 1994).

A second example is where K-mart and Eastman Kodak exchange point-of-sale data. With this information Kodak automatically replenishes K-Mart distribution centers by TL rather than individual stores by LTL. The K-mart distribution centers then sort and consolidate into larger shipments to individual stores (Traffic Management, May 1992).

A computer manufacturer learned that shipping by air instead of ocean for one of its supply chain links, could save millions in inventory investment. These savings come from intransit inventory and shorter delivery lead times. Moreover, distribution centers need less safety stock to provide the same level of customer service. The benefits outweigh the costs, even though air freight costs three times that of ocean (Sloan Management Review, Spring 1992).

Nabisco Foods defines Effective Consumer Response (ECR) as an implementation of a supply chain initiative that began in the food industry enabling companies to drive out costs through increased cooperation and communication between various links of the channel. Part of this approach, Continuous Replenishment (CRP) is new. With CRP, the inventory bubble shifts from the customer back to the manufacturer yielding the following realizations:

1. Retailers are starting to feel that manufacturers today are better inventory managers.

2. Trust, as expressed in a willingness to share information, is improving with respect to relationships between members of the supply chain.

3. Manufacturers find that there is a need to work with trading partners to convince them to avoid the high/low relationships when buying for promotion, but rather to determine an every day low price. The use of CRP and stable inventories keep costs/prices lower, resulting in savings to be passed to the consumer.

1.3 Logistics Strategy

(a) Background

Logistics deals with much more than just the pick-up and delivery of products to and from customers. It entails the process of getting raw materials from suppliers, maintaining inventory (raw materials and finished goods), transportation of materials to and from suppliers/customers, consolidation of shipments, and many other functions. Historically, logistics has had a cost-based, operations orientation, that is, the primary focus of logistics management was on providing logistics systems that minimized cost of logistics-related services. However, in leading-edge corporations today, high quality logistics service is used strategically to differentiate firms from their competitors (Coyle).

Logistics strategies designed to address customer expectations regarding delivery of products in turn define the character of demand for freight transport. These demand characteristics can be defined along the following dimensions (from the perspective of the shipper):

- Geographic coverage: local, national, continental, global.

- Shipment size (weight or volume): parcel, less than truckload (LTL), full truckload (TL), multiple TL or rail carload. The heavier the shipment, the lower the transport costs per unit weight. However, for mixed-commodity packaged freight as well as single commodity shipments transported in dry van truckload quantities, transport rates are increasingly quoted on a per-load basis without regard to weight.

- Frequency of delivery: hourly, daily, weekly. Assuming a given demand over a given time period, the higher the shipment frequency (same as shorter time between dispatches), the smaller the shipment size and the greater the total cost of transport.

- Speed: the lead or order cycle time between when an order is placed by a customer of the shipper until that order is delivered to the customer. Includes order transmittal, processing, picking, and shipment delivery time. Vehicle speed affects only the latter. In general, shipments peddled or sent through consolidation centers have lower average speeds than direct shipments. Also, generally order cycle times are more compressed for higher value and shorter shelf life products.

- Quality/reliability of service: providing service on-time at agreed upon service level i.e., 95 percent, 98 percent, 99 percent. Uncertainty of delivery raises inventory cost on the supply channel and forces the holding of safety stocks.

- Quality/condition of delivered product: physical condition of the product delivered. Requires varying combinations of temperature, humidity, handling, and vehicle cushioning control depending upon the product transported.

- Flexibility: responsiveness to changes in customer's needs. Has an increasingly important time dimension, particularly in retail goods distribution and in JIT production systems. Often a function of carrier equipment availability, or the ability to change transportation strategies already put in place.

- Service coverage: linehaul only, one origin-destination door-to-door, multiple origins-destinations door-to-door.

From a shipper's perspective, shipment size is a function of many factors, including the size of orders placed by customers and the physical capacity of the transport vehicle. The fundamental trade-off in determining optimal (least-cost) shipment size is between transportation costs and inventory holding or carrying costs. This trade-off is typically assessed through the application of some form of an Economic Order Quantity (EOQ) model. These models express total cost as the sum of inventory-carrying and transportation costs. Inventory-carrying cost is difficult to estimate precisely. In addition to the opportunity cost of capital, carrying cost depends on product value, annual volume, insurance, handling, storage, and obsolescence costs of holding inventory. Inventory-carrying cost is a direct function of shipment size because, as shipment size increases, the size of average inventories rise.

Transportation cost is the freight charge per unit of shipment. As shipment size increases, transportation costs per unit tend to fall because most transport operating costs do not increase in proportion to increases in the weight of the vehicle. Due to these shipment size economies, transport cost is inversely related to shipment size. Figure 2 presents a graphical representation of the EOQ model (Blumenfeld et al.). This figure shows the tradeoff necessary between reducing transportation costs by increasing the shipment size and the associated increased inventory carrying cost. EOQ models typically attempt to find the shipment size that corresponds to the minimum point on the total cost curve, C.

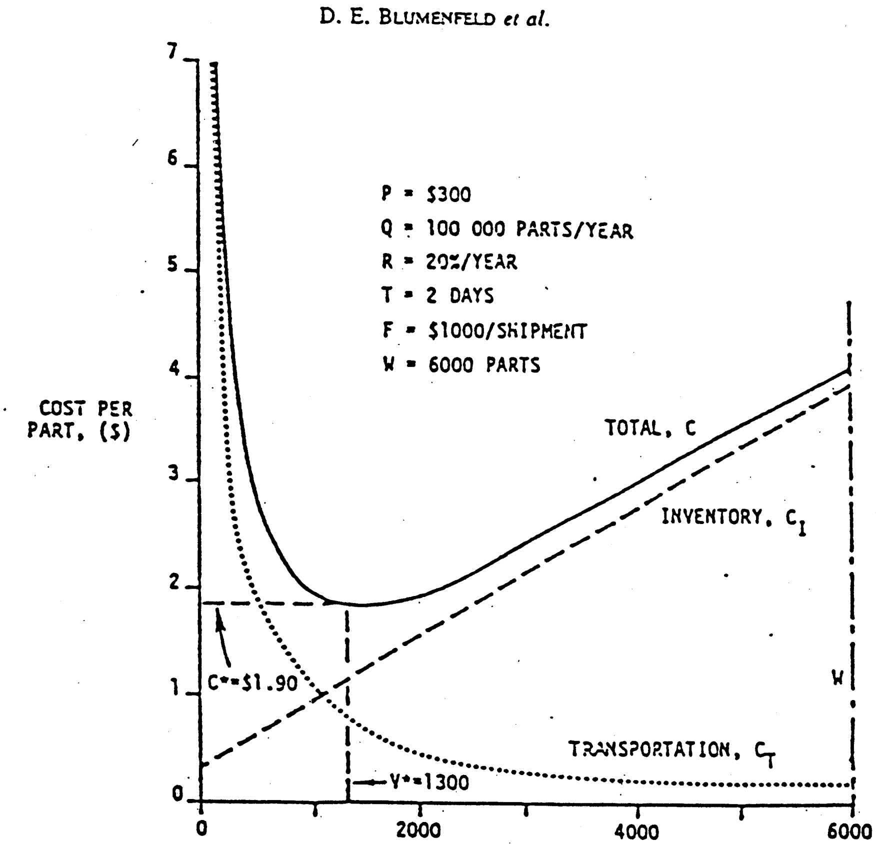
Shipment sizes vary considerably depending upon the type of commodity being shipped and on where in the supply chain the shipment is being made. The next two sections address these matters.

(b) Commodity Groups

Logistics practices, including size of shipments, vary widely depending on the type of commodity or product under consideration. As commodity value increases, all other factors held constant the cost of holding that product in inventory increases and therefore efforts intensify to reduce the amount of inventory held at storage facilities as well as in transit. Time sensitivity describes the importance of having a specific product or commodity in a specific place at a specific time. It can also be used to describe products or commodities that quickly become obsolete or outdated. Similar to value, as the time sensitivity of a product increases, firms attempt to decrease the amount of inventory. Transit times can be affected by shipment size due to the manner in which shipments are handled by carriers. Shipments in the 500-10,000 pound weight range tend to move through less-than-truckload networks and thus tend to move more slowly than either small shipments handled by express carriers or truckload shipments that move directly from shipper to receiver.

The four commodity groups considered for this analysis are: 1) High-Value, Time Sensitive; 2) Low-Value, Time Sensitive; 3) Non-Time Sensitive; and, 4) Bulk.

Figure 2. Total Cost per Part vs. Shipment Size



High-Value, Time-Sensitive, Packaged Goods

Products from companies such as Hewlett-Packard, The Limited, and Iowa Beef Products fall into this category. Typically of very high value per pound, these products may require specialized equipment and facilities for storage and transportation, and typically must be delivered within specified time windows. These characteristics all add to the cost of transporting goods and maintaining inventory. As the cost increases and the time window for delivery decreases, this tends to reduce the optimal shipment quantities for these products. For example, The Limited's products are very time sensitive regarding delivery to retail outlets. Fashion items have a highly compressed product development life-cycle. Consequently, if garments are not in the store at the time the consumer wishes to purchase, the sale often is lost.

Low-Value, Time-Sensitive, Packaged Goods

This commodity group can best be categorized by many of the food and grocery supply products. On a per-item basis, these products do not have high product values but they are relatively sensitive to time. Food products can spoil and once they exceed their "shelf-life", the product must be scrapped. For this commodity group, the concern may not be as much on the cost of holding and maintaining the inventory as it is the need to deliver product at a specific time.

Non-Time Sensitive

Semi-processed and finished lumber products fall into this category.

Bulk

Bulk products, like coal and potash, are typically low value items, transported and consumed in very large quantities, and typically not transported by road over very long distances due to the relatively high ratio of transportation costs to product value. Inventory holding costs are usually not an issue, consequently, these products are ordered in sufficient quantities to allow delivery in bulk (unit-train, truckload, etc.) so as to reduce unit transportation costs.

(c) Product Distribution Patterns

A variety of product flow patterns have evolved over time as supply and distribution networks become more complex. The simplest flow pattern is point-to-point. This type of pattern is characteristic of products using super express courier services or TL carriers. Point-to-point product flow is also found on breakbulk terminal-to-terminal portions of LTL networks.

A one-origin-to-many-destinations product flow is characteristic of products originating at one point, such as a manufacturing plant or distribution center, and distributed directly to many distribution points or customers. This type of flow pattern requires more sophisticated planning and routing to achieve efficient vehicle utilization and meet customer needs. Vehicle consolidation of the product flow can bring significant transport cost savings. These types of flows are found in retail distribution and on the customer delivery legs of LTL operations. Peddling is a term often given to this type of product distribution. On a peddle run, the vehicle is dispatched with multiple shipments and one shipment is dropped off at each of the destinations on the run. The converse of the one-to-many product flow is the many-to-one flow. This is characteristic of pickup operations in LTL networks.

A many-to-many product flow pattern is characteristic of express carrier services such as UPS and Federal Express and of complete LTL networks. Products originate at many different points and must be distributed to many different points. Consolidation terminals are important components of these networks. These terminals serve to sort and assemble the flow of product through the network to achieve optimal utilization of vehicles and to lower transport costs. The speed at which this sorting and assembly takes place is evermore important in today's competitive transport environment. The many-to-many flow patterns can become quite complex, with the most time-sensitive products flowing through just one consolidation point, while other products may flow through two or more consolidation terminals.

The trend toward smaller shipment sizes and more frequent deliveries increases transport costs (Whitford). To keep these costs from rising too high, more sophisticated consolidation strategies than those typically used by LTL carriers are being developed (Anderson and Quinn). These strategies are responding to the demands on shipment time, frequency, and quality.

(d) Alternative Transportation Patterns

<u>Direct Shipping</u>

For direct shipping (shipping directly from supplier to customer), the transportation costs per load are assumed to be a function of: 1) fixed cost of initiating a dispatch; 2) fixed cost of a customer stop; 3) transportation cost per mile; and 4) round trip linehaul distance. One problem with most EOQ models is that the modeling of transportation cost is independent of the load size, weight, or vehicle capacity.

Further model development by Abdelwahab and Sargious focused on developing a relationship between transportation rates and shipment size to substitute for the fixed transportation charge in earlier models. Their refined model calculates a cost for a full truckload as a function of the distance traveled, the shipment size (pounds), the commodity value ($/lb) and commodity density (lb/ft^3). Using this model, it can be shown that as the usage rate or demand increases, the optimal shipment size increases. As the value of the product increases or the inventory carrying charge rises, total cost per unit rises but optimal shipment sizes decline as more emphasis is given to reducing average inventory levels. Also, as distance increases, costs rise and optimal shipment size increases.

While Abdelwahap and Sargious' work does advance the modeling of freight distribution, there are still problems with the theoretical models. These models all assume that the transportation time is known and exact. They do not account for any variability in transit times. Influences such as congestion, availability of dock space either at the shipper or receiver, and weather characteristics all can impact the amount of time it takes a vehicle to make a delivery or pick-up.

Using shipper data and EOQ-based model results supplied by Penn State University, Middendorf and Bronzini in a study for the Federal Highway Administration analyzed the potential cost impacts on shippers from the use of longer combination vehicles (LCVs). The LCV configurations studied for this effort were the Rocky Mountain double combination consisting of a tractor pulling a 48-foot trailer followed by a 28-foot trailer and the turnpike double combination which is a tractor pulling two 48-foot trailers. Based on their research, Middendorf and Bronzini found that in most cases, use of LCVs would have a significant favorable impact on the annual total logistics cost of truckload shippers. In shipping lanes with moderate to high volumes (between two firms), long distances between origin and destination, or medium to low product unit values, the economies of shipment size made possible by larger capacity transport vehicles more than offset the higher inventory costs associated with larger shipment sizes.

While many variables factor into the determination of potential benefits associated with using LCVs, an "... excellent indicator of whether or not a truckload shipper would benefit from switching to LCVs is the ratio of the shipper's current annual single trailer freight costs to annual inventory carrying costs." Since the use of LCVs increases the capacity of transport vehicles and thus increases the amount of inventory in transit, a tradeoff is established between the cost savings associated with the productivity increases versus the cost penalty associated with higher inventory carrying costs. Based on their research, Middendorf and Bronzini found that "... when single trailer freight costs are two or more times greater than the inventory carrying costs, switching from single trailers to LCVs will in all likelihood greatly reduce the shipper's annual total logistics costs."

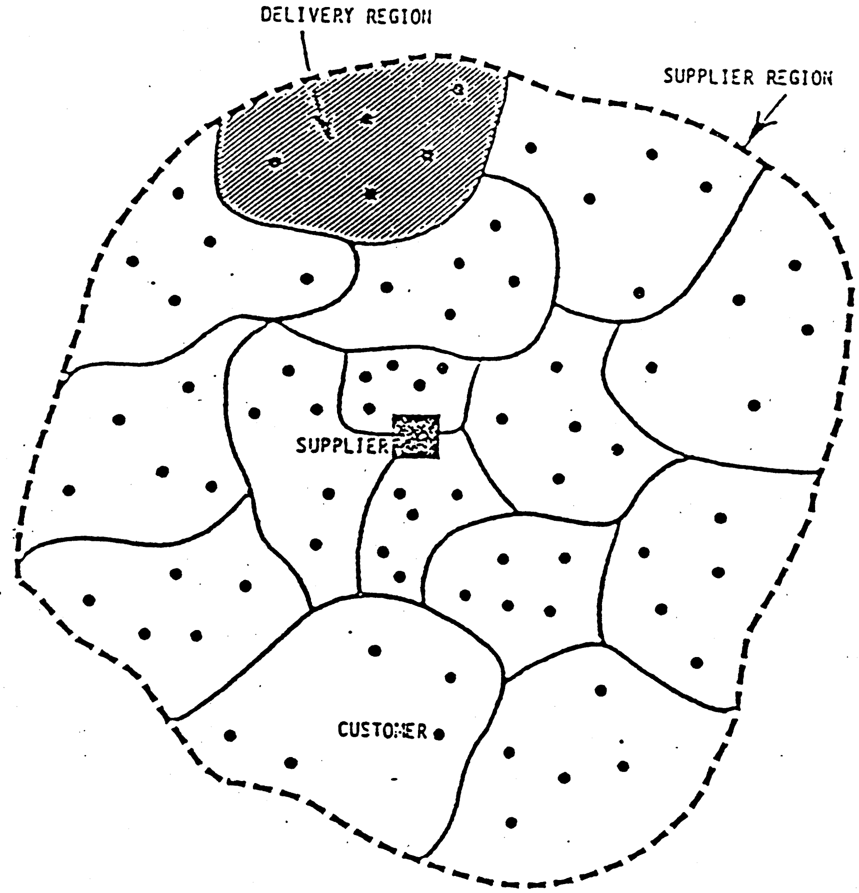
While this gives very good information regarding potential uses for LCVs, it has limitations. The data under study were only for truckload shipments and received from a relatively small sample size of 176 product-specific traffic lane (origin-destination) movements obtained from a total of 72 companies. This study did not address any of the potential impacts on LTL shipments or other size and weight configurations except those modeling. Also, there is no way to determine at this time how representative the sample is of the population; thus, any generalizations must be made with caution. If the distributions of annual lane volumes, shipment distance, or product volumes obtained in the same are highly skewed, then very different results might arise from a more representative sample.

Peddling

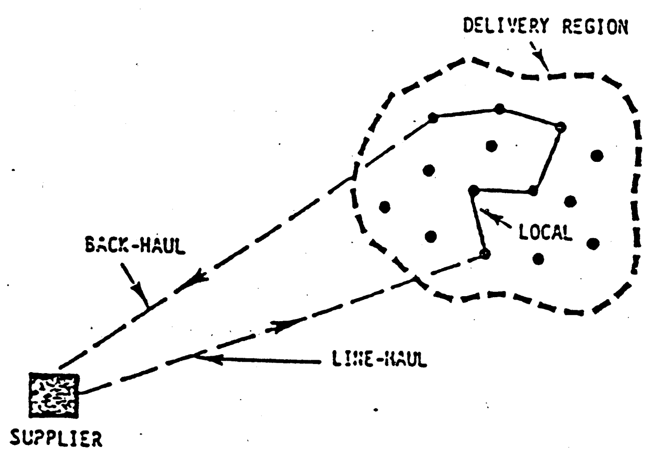
For a given production volume, as the number of customers increase, the cost of direct shipping rises. So, when a supplier is serving many customers, and the typical customer orders are small, then alternatives to direct shipping are worthy of exploration. One alternative explored by Burns, et.al., is "peddling" (also referred to as milk runs) defined as the shipment of multiple customer orders in one vehicle that makes multiple stops on a peddle run emanating from and returning to the supplier's location. Figure 3 from Burns et al., shows a typical supplier customer relationship where multiple customers are served by one supplier. The customers are divided up into delivery regions in which a peddling run can be made to each region. While the work done by Burns et.al. described peddling a supplier's goods to customers, the same model and conclusions could be used to model the pick-up and delivery of parts or materials from multiple suppliers for delivery to a producer.

The direct shipping model described above cannot be used as-is for peddling because it does not account for local delivery transportation costs. Local delivery transportation costs are dependent upon the size of the delivery region. For this approach, Burns et.al. account for the number of customers in a given delivery region and the number of customer stops per

Figure 3. Typical Supplier and Customer Relationship



Delivery regions.



Peddling stages.

vehicle load. The general concept of peddling is to fill the vehicle to capacity at the supplier, and then make a single line-haul/back-haul trip to the region while making multiple local deliveries within the region. As the size of the region decreases and the density of customers within the region increases, this type of peddling approach becomes more attractive.

Still, the peddling model described by Burns et.al. does not account for any travel-time uncertainties. It basically assumes that the more stops you can make on a single trip, the better. From a transportation cost standpoint this may be true. However, it does not account for the time value of deliveries. As more and more production facilities are moving to just-in-time supply chain practices, adding product and stops to a peddling or milk run may add significantly to the time required for delivery and/or pick-up of the product. In work done studying the delivery of prepared foods in the grocery industry, one major manufacturer has found that a limit of three stops per peddle run was about the maximum that could be planned for when accounting for actual traffic uncertainties, delivery schedules, and other unforeseen delays to the delivery process.

The peddling/pick-up cost advantage is most dramatic on short-distance, high-value, low-time period volume shipments. The peddling cost advantage increases at a decreasing rate with linehaul/backhaul distance. It also increases with customer density, item value, inventory carrying charge, and customer demand.

1.4 Supply of Transport

With the advent of just-in-time production and supply systems, there is a growing trend toward frequent and small deliveries of supplies and products. The higher the unit value of the goods, the lower transportation costs tend to be as a share of total logistics costs due to higher opportunity and other costs of maintaining inventories. Consequently, market incentives exist which promote smaller and more frequent shipments. Regulations which allow greater weights and/or LCVs are unlikely to provide universal benefits for producers of high-value or time-sensitive commodities.

A similar relationship between transportation and inventory costs exists in shipping lanes where the annual volume moving between two firms is low or the distances between the firms are short. As annual lane volume declines or as lane distance decreases, transportation costs decline relative to inventory costs. Again, the lower transportation costs made possible by larger dimension vehicles and/or LCVs are likely to be more than offset by higher inventory costs so that there is no net benefit for shippers in these circumstances.

An exception to these generalities is the case in which less-than-truckload (LTL) carriers move a consolidated shipment from terminal to terminal in a truckload (TL) line-haul fashion. In this case, shippers and carriers may benefit from greater weight allowances or LCVs, provided the carriers can consolidate the larger loads without decreasing levels of service (shipment time and reliability).

Shippers of low-value, non-time-sensitive commodities shipped directly from supplier to customer via TL shipments would benefit from greater weight allowances or LCVs. So would shippers that ship high volumes between two points or over long distances. If single-trailer freight costs are high relative to the cost of maintaining inventories, shippers would benefit from the greater carrying capacity of LCVs, and their annual logistics costs would decrease. The proportion of product cost represented by transportation would be reduced, ultimately lowering the cost of goods and services, resulting in net benefits to society. This is true also for bulk products (e.g., coal or grain) which are occasionally shipped via truck and are generally not time sensitive. Table 1 summarizes those commodity characteristics and shipping patterns where larger vehicle dimensions and/or LCVs would provide the most beneficial impact from a logistical standpoint.

Table 1. Where Larger Truck S&W Will Have the Most Beneficial Impact

<u>Commodity Characteristics</u>
Low Value
Non-Time Sensitive
<u>Shipping Patterns</u>
On terminal-to-terminal portions of LTL
Point-to-point TL (depending upon commodity characteristics)
Peddle or milk runs (depending upon commodity characteristics and density of stops)
Long distance shipments
High annual volume between two firms

3.0 References for Logistics Working Paper

Abdelwahab, Walid M. and Sargious, Michael, "Freight Rate Structure and Optimal Shipment Size in Freight Transportation," Logistics and Transportation Review, Volume 26, Number 3, pp. 271-292.

Anderson, David L. and Quinn, Robert J., "The Role of Transportation in Long Supply Line Just-in-Time Logistics Channels," Journal of Business Logistics, Volume 7, Number 1 (1986), pp. 68-88.

Apogee Research, Inc., "Case Studies of the Link Between Transportation and Economic Productivity," Final Report, prepared for the Federal Highway Administration, January 1991.

Burns, L.D., Hall, R.W., Blumenfeld, D.E., and Daganzo, C.F., "Distribution Strategies that Minimize Transportation and Inventory Costs," Operations Research, Volume 33, Number 3, May-June 1985, pp. 469-480.

Blumenfeld, D.E., Burns, L.D., Daganzo, C.F., Frick, M.C. and Hall, R.W., "Reducing Logistics Costs at General Motors," Interfaces, 17(1), 26-47, Copyright, 1987, The Institute of Management Sciences, USA.

Blumenfeld, D.E., Burns, L.D., Diltz, J.D., and Daganzo, C.F., "Analyzing Trade-Offs Between Transportation, Inventory and Production Costs on Freight Networks," Transportation Research, Volume 19B, Number 5, pp. 361-380, 1985.

Bower, Joseph L. and Hout, Thomas M., "Fast-Cycle Capability for Competitive Power," Harvard Business Review, November-December 1988, pp. 110-118.

Bylinsky, Gene, "The Digital Factory," Fortune, November 14, 1994, pp. 92-110.

Christopher, Martin (ed.), Logistics, The Strategic Issues, Chapman & Hall, London, 1992.

Cooke, James Aaron, "Supply Chain Management '90s Style," Traffic Management, May 1992, pp. 57-59.

Coyle, J. J., Bardi, E., and Langley, J., Business Logistics Management, 5th ed., West Publishing Co., 1994.

Dumaine, Brian, "How Managers Can Succeed Through Speed," Fortune, February 13, 1989, pp. 54-59.

"Easing Highway Congestion," The Journal of Commerce, March 5, 1991.

Ellram, Lisa M. PH.D., CPM, "The `What' of Supply Chain Management," NAPM Insights, March 1994, pp. 26-27.

Hall, R.W., "Consolidation Strategy: Inventory, Vehicles and Terminals," Journal of Business Logistics, Volume 8, Number 2 (1987), pp. 57-73.

Hall, R.W., "Dependence Between Shipment Size and Mode in Freight Transportation," Transportation Science, Volume 19, Number 4, November 1985, pp. 436-444.

Henkoff, Ronald, "Delivering the Goods," Fortune, November 28, 1994, pp. 64-78.

Hill, Arthur V. and Vollman, Thomas E., "Reducing Vendor Delivery Uncertainties in a JIT Environment," Journal of Operations Management 6, August 1986, pp. 381-392.

Lee, Hau L. and Billington, Cory, "Managing Supply Chain Inventory: Pitfalls and Opportunities," Sloan Management Review, Spring 1992, pp. 65-73.

Lieb, Robert C. and Miller, Robert, "JIT and Corporate Transportation Requirements," Transportation Journal, Spring 1988, pp. 5-10.

Middendorf, David P. and Bronzini, Michael S., "The Productivity Effects of Truck Size and Weight Policies," prepared for the Federal Highway Administration and Center for Transportation Analysis, Oak Ridge National Laboratory, November 1994.

Perry, James H., "Firm Behavior and Operating Performance in Just-in-Time Logistics Channels," Journal of Business Logistics, Volume 9, Number 1 (1988), pp. 19-33.

Rao, Kant and William L. Grenoble, "Modeling the Effects of Traffic Congestion on JIT," International Journal of Physical Distribution and Logistics Management, (forthcoming)

Rao, Kant, Grenoble, William L. and Young, Richard R., "Traffic Congestion and JIT," Journal of Business Logistics, Volume 12, Number 1 (1991), pp. 105-120.

Rao, Kant and Young, Richard R., "The Impact of Heavier Vehicle Weight Limits on the Transloading of Ocean Containers," International Journal of Physical Distribution and Logistics Management, Vol. 22, No. 7, (1992), pp. 25-34.

Richardson, Helen, "Can We Afford the Driver Shortage?", Transportation and Distribution, August 1994, pp. 30-34.

Stalk, G. Jr., "Time - The Next Source of Competitive Advantage," Harvard Business Review, July-August 1988, pp. 41-51.

Whitford, R.K., "Aspects of Freight Service Quality for Just-in-time Transportation Serving the U.S. Automobile Industry," Presented at "Just-in-Time Transport: New road Freight Transport Strategies and Management: Adapting to the New Requirements of Transport Services," research Seminar, June 22-24, 1987, Gothenburg, Sweden.

Wisdo, Joseph, Nabisco Foods, "The Supply Chain Revisisted," presentation/discussion at Penn State's Center for Logistics Research- Logistics Leaders Forum IV, The Supply Chain Revisited, September 1994.