Policy Issues of an Iowa Longer Combination Vehicle Network

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Midwest Transportation Center

Midwest Transportation Center
Iowa State University
2521 Elwood Drive - Suite 125
Ames, IA 50010
Telephone: 515-294-8103
FAX: 515-294-0467

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Tom Maze, Co-Principal Investigator
Professor, Department of Civil and Construction Engineering
Director, Iowa Transportation Center
Iowa State University

Clyde K. Walter, Faculty Associate
Associate Professor, Department of Transportation and Logistics
College of Business
Iowa State University

Ayman Smadi, Research Associate
Upper Great Plains Transportation Institute
North Dakota State University
(Formally: Research Associate, Iowa Transportation Center, Iowa State University)

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Executive Summary

The purpose of this report is to explore policy issues related to Longer Combination Vehicles (LCVs) and the potential expansion of the LCV network to include Iowa. LCVs are vehicles with size and/or weight dimensions which exceed the maximum standards for the National Highway Network as defined by the Surface Transportation Assistance Act of 1982. Because LCVs exceed these maximum standards, LCV operation along highways governed by multiple jurisdictions (within states and highways operated by toll authorities) has been allowed under special divisible load permits. The system of highways where LCV operation is allowed was frozen at its 1991 coverage by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. In this act, Congress suspended potential increases in the existing LCV highway network until it receives adequate information to evaluate the benefits and costs of further expansion of the LCV network.

Under the broad definition of LCVs as vehicles exceeding the maximum size or weight dimensions of the STAA of 1982, jurisdictions decide the size and weight dimensions that define vehicle as LCVs and the safety and operating regulations governing them. As a result, current size and weight laws governing LCVs in those jurisdictions (states and toll authorities) permitting the operation of LCVs is a patchwork of non-uniform size and weight regulations. The specific LCV configurations, axle weights, and gross weights permitted in each jurisdiction is largely based on unique prescriptive standards for size and weight dimensions. Further, each jurisdiction may have additional safety and operating regulations for LCVs and constraints limiting LCV operation to a defined network of highways.

Such a patchwork of non-uniform regulations can create confusion over what constitutes an LCV. Therefore, for the purposes of this report, LCV configurations are divided into three classes:

- **Triple**. A tractor pulling three 28-foot trailers.
- **Turnpike Double**. A tractor pulling two 40- to 48-foot trailers.
- **Intermediate Length Double**. A tractor pulling two trailers where the first trailer is longer than 28 feet and up to 48 feet in length and the second is shorter than 40 feet.

One of the principal benefits of the ability to employ LCVs is that it allows motor carriers to make equipment investment and use decisions based on freight characteristics and market needs. Where LCVs are allowed, motor carriers have more flexibility to select vehicle configurations which are best suited for the particular market segments being served. For example, triples are primarily a tool for the less-than-truckload (LTL) segment of the industry. In LCV corridors where the traffic density is great enough to support the use of triples, a motor carrier has the flexibility to use triples on the line-haul segment of the trip. In addition to greater flexibility, motor carriers employing LCVs accrue greater productivity through greater volume and/or weight carrying capacity. Because common LCV configurations are attractive only to specific segments of the truck services market, the report provides a descriptive analysis of Iowa's current truck and rail freight traffic. This descriptive traffic analysis attempts to define which Iowa freight traffic segments will be affected by potential size and weight changes that would allow LCVs to operate over selected portions of the Iowa highway system.

As Congress moves toward the reconsideration of allowing states to expand the LCV network, several forces are placing pressure on transportation policy makers to consider potential truck size and weight reforms. These include:

- Harmonizing U.S. truck size and weight standards with Mexico and Canada as required by the North American Free Trade Agreement (NAFTA).
- The need to promote uniform size and weight regulation among all jurisdictions and among jurisdictions which permit LCVs.
- Pressure to move size and weight regulation from their historically defined prescriptive standards to standards which control for the performance of the vehicle with respect to pavement and bridge deterioration and vehicle safety.
- Pressure from the motor carrier industry to accrue additional productivity gains through relaxation of size and weight regulations.

Assuming ISTEA's freeze on the expansion of LCV networks is relaxed, state and federal regulators will again have to consider the issue of size and weight reform. When considering reform of size and weight laws, states like Iowa must recognize that current LCV configurations were based on prescriptive standards and these standards may not be the most desirable configurations for larger trucks in terms of safety and pavement and bridge wear performance. Thus jurisdictions may need to adopt new approaches to size and weight regulation to ensure LCV size and weight limits reflect real world limitations.

Any consideration of reform will require truck size and weight regulators to make decisions on managing the supply of LCV systems. Truck size and weight regulators can control the supply of an LCV system through four primary variables:

- The vehicle configurations and size and weight limits permitted to operate.
- The extent and coverage of the network of roadways over which larger vehicle are permitted to operate and the uniformity of the network with those of states within the region.
- Access provided to the network.
- Safety restrictions placed on the weather and environmental conditions in which larger vehicles may operate, fitness and experience of the drivers, and equipment condition.

The final chapter of the report addresses a number of additional policy issues that must be considered when appraising possible relaxation of size and weight regulations. Of these issues, one chief consideration will be the assessment of user fees on larger vehicles that recover the costs of allowing their operation. These user fees must equal the cost of making the necessary geometric improvements to allow the safe operation of larger vehicles, the added costs of ancillary facilities to support the use of longer vehicles (e.g., staging facilities for longer combinations), and the costs of any additional bridge and pavement wear resulting from heavier vehicles.

Chapter 1
Introduction and Longer Combination Vehicle Background

This report will begin to explore some of the policy issues related to Longer Combination Vehicles (LCV) and the potential expansion of the LCV network to include highways within the state of Iowa. Specifically, the transportation service impacts and public policy issues will be examined. A companion effort at the University of Iowa is devoted to exploring the infrastructure issues related to the physical impacts of LCV use on highways and bridges.(1)(2)

To begin any discussion of LCVs, some definition of what constitutes an LCV is needed. Several truck combinations have been grouped into the categories of LCVs. Generally, these are truck combinations exceeding the maximum dimensions, combination of trailers, and/or weight permitted nationally by the Surface Transportation Assistance Act (STAA) of 1982. The STAA created a uniform standard for maximum truck weight, dimensions, and permissible combinations. All states were required to allow trucks complying with maximum uniform standards to operate on the National Highway Network. [1] The National Highway Network includes about 60 percent of the federal-aid primary system, roughly 138,600 miles of primary roads, and virtually all the Interstate Highway System, roughly 44,300 miles of Interstate Highways. As summarized in a TRB Special Report (3), the principle uniform requirements of the STAA of 1982 were:

- Trailer length: The act specifically prohibits states from limiting the length of the semitrailer in a tractor-semitrailer combination vehicle to less than 48 feet, or of each trailer in a combination vehicle with two trailers (i.e., twin trailers, commonly called Western Doubles) to less than 28 feet on specific highways.

- Number of trailers: The act specified that states could not prohibit the use of twin trailer trucks on highways designated for their use.

- Overall combination vehicle length: The act prohibited states from enacting any overall length limit on tractor-semitrailer or on twin trailer trucks.

[1] The National Highway Network should not be confused with the National Highway System mandated by the Intermodal Surface Transportation Efficiency Act of 1991.

- Grandfathered length limits: The act required states to continue to allow trailers that were actually and lawfully being operated before the passage of STAA, even though they exceed the maximums under the STAA of 1982.

- Vehicle width: Existing federal limits on truck width were liberalized. States were required to adopt the new federal standard of 102 inches.

- Axle Weights: The act required states to increase their single-axle limits to 20,000 pounds, tandem-axle limits to 34,000 pounds, and their gross weight limits to 80,000 pounds.

LCVs are vehicles that exceed one or more of the maximum standards established by the STAA of 1982. In general, LCVs are composed of a combination allowed under the STAA of 1982 plus one additional trailer. This study will focus on three types of LCVs as defined in a Trucking Research Institute report (4):

- Triple: Typically, a triple is a two-axle tractor pulling one 28-foot semitrailer (really 28.5 feet) and two 28-foot trailers. The result is a seven-axle combination with an overall length in excess of 100 feet. With seven axles, a triple could have a gross vehicle weight (GVW) of over 130,000 pounds without going over the 20,000 pound single axle limit. State and turnpike authorities that currently allow triples have maximum GVWs on triples varying from 80,000 pounds (in Colorado) to 129,000 pounds (in Utah). (5)

- Turnpike Double: Typically, a Turnpike Double is a three-axle tractor pulling a 40- to 48-foot semitrailer and a 40- to 48-foot trailer. The result is a nine-axle combination well over 100 feet in length. With four tandem axles and a steering axle, a Turnpike Double could have a GVW over 140,000 pounds without going over the single and tandem axle limits. State and turnpike authorities that currently allow Turnpike Doubles have maximum GVW on them varying from 80,000 pounds (in Colorado) to 143,000 (on the New York State Thruway).

- Intermediate Length Double: Typically, this is three-axle tractor pulling a semitrailer longer than 28 feet and a trailer 28 feet or longer. Intermediate Doubles are longer than Western Doubles (a tractor pulling a 28-foot semitrailer and 28-foot trailer) but are shorter than a Turnpike Double. Intermediate doubles include even-length semitrailer and trailer combinations over 28-foot per trailer. For example, a tractor pulling a 33-foot semitrailer and 33-foot trailer would be classified as an Intermediate Double. The most common Intermediate Double is the Rocky Mountain Double, which typically consists of a 40-foot semitrailer pulling a 28-foot trailer. Some western states which permit Intermediate Length Doubles have minimal restrictions on the highways where they may be used. For example, Wyoming allows Intermediate Doubles on the entire state highway system.

Currently, LCVs can be operated on the highways and turnpikes in 20 states[2].(6) Generally, each state or turnpike that allows LCVs to operate on its roadways has adopted slightly different maximum size and weight dimensions, varied operational requirements (e.g., access to and from LCV networks, time of the day when LCVs may operate, and weather conditions when LCVs may operate), and varied equipment and operator safety standards for operation. Further, each configuration of an LCV is most appropriate for different freight market niches representing varied segments of the truck transportation service market. For example, triples are attractive vehicles for the less-than-truckload segment and turnpike doubles are a tool for the truckload industry. It is important to recognize that LCVs have diverse physical and operational requirements in each jurisdiction and that they serve diverse segments of the trucking industry. The heterogeneity of uses makes it difficult to generalize LCV performance. However, all LCVs have dimensions that exceed the maximums set by the STAA of 1982.

WEIGHT AND LENGTH LIMITS

The establishment of maximum limits for truck size and weight have traditionally been the responsibility of states. The first weight legislation measures were passed in 1913 in Maine, Massachusetts, Washington, and Pennsylvania.(7) Later, Pennsylvania's axle limit of 18,000 pounds was adopted as a basic element for the design of pavements and used as a maximum axle load on Interstate Highways until 1974. By 1933, all states had adopted some kind of truck size and weight regulation.

In 1932, the American Association of State Highway Officials (AASHO), which later became the American Association of State Highway and Transportation Officials (AASHTO), recommended a 16,000 pounds axle load limit. AASHO later revised its policy in 1946 and

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2 Technically, there are 30 states where LCVs can legally operate. For example, Missouri is generally not considered an LCV state but it provides permits to motor carriers operating LCVs along the Kansas Turnpike in order to provide access to their terminals in the Kansas City area. As another illustration, Louisiana and Mississippi permit trucks to operate with twin trailers longer than 28 feet. Trucks are permitted in both states with twin trailers up to 30 feet on a case by case basis. However, for purposes of this report, only the commonly accepted 20 states are considered LCV states.

recommended a single-axle load limit of 18,000 pounds and a tandem-axle limit of 32,000 pounds.(8) To limit the stress on bridges, the AASHO policy recommended a maximum weight limit of 73,280 pounds for vehicles with extreme axles at least 57 feet apart. The maximum weight limits were based on the Bridge Formula, which determines gross weight based on the distance between axle extremes in any set of an axle group.

The Federal-Aid Highway Act of 1956 applied the AASHO standard to the Interstate Highway system. The act also allowed states to continue to use weight and size limits greater than the those recommended in the AASHO policy, thus grandfathering higher weight and size limits in place.

In 1974, Congress adopted increased axle limits of 20,000 pounds per single-axle and 36,000 pounds per tandem-axle. It also adopted a revised bridge formula to allow gross vehicle weight to increase to 80,000 pounds. The new axle and gross weight limits were caps for states that did not already have higher limits. Other states that already had higher limits were allowed to grandfather the higher pre-existing limits. States that did not want to increase their weight limits to the higher limits on the Interstate Highway System could stay at prior gross weight and axle load levels. The 1974 legislation (as well as the 1956 legislation) included provisions for states that already issued permits for oversize and/or overweight trucks to continue to exercise that authority.(9) Under overlength and oversize permit authority, some states allowed LCVs to operate through the state's permitting process.

The STAA of 1982 removed the option of states to have lower than the uniform standard for weight limits on the National Highway Network, thus promoting uniformity. With few exceptions, states could no longer impose limits on weights, widths, lengths, or combinations that were more restrictive than the Federal limits. The STAA introduced an increased Federal role in vehicle size and weight regulation by preempting the state's right to limit overall length of singles or doubles and requiring "reasonable access between the National Highway Network and terminals and facilities for food, fuel, repairs, and rest."(10) The STAA also grandfathered state limits that exceeded Federal limits and continued to allow states to authorize the operation of larger trucks under special permits.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 froze current limits on the use of LCVs to highways where states permitted LCVs as of June 1, 1991.(11)

The Act also prohibits those states currently allowing the operation of LCVs to expand routes or expand restrictions on LCV use.[3] Specifically, ISTEA "restricts the operation of longer combination vehicles on the Interstate Highway System and commercial motor vehicle combinations with two or more cargo carrying units on the National Highway Network to the type of vehicle in use on or before June 1, 1991, subject to whatever State rules, regulations, or restrictions were in effect on that date."(12) ISTEA does not restrict states from continuing to issue special permits for vehicles which exceed the restricted size limits but carry loads which cannot be easily dismantled or divided (non-divisible loads).

It is not clear from the legislation when or if the freeze on expanding LCV routes will be lifted. However, Congress requires the FHWA to determine if changes to the Federal LCV law are needed. To provide the information FHWA needs to determine if it should recommend changes, FHWA is to conduct road tests of LCV drivers and vehicles. FHWA is required to submit the results of the road tests by December 18, 1994. In addition, the Comptroller General will conduct a study of LCV safety and performance characteristics and compare LCVs to other truck combinations. The Comptroller General's study, also due to Congress on December 18, 1994, will specifically assess(13):

- State initiatives pertaining to LCV safety;
- Available data on LCV safety;
- The economic impact of LCVs.

The General Accounting Office produced three reports to congress addressing the three above and thus fulfilling Comptroller General's requirements.(14)

Safety is the key issue. Opponents to expansion of the LCV network promoted the ISTEA freeze on LCV operations due to safety concerns over larger trucks in the traffic stream. Clearly, Congress intends to reconsider expansion of the LCV network or new rules governing LCVs when the mandated studies are completed.

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[3] Exceptions to the freeze were made for the states of Wyoming, Ohio, and Alaska. In each case, the state had enacted changes which were to take effect after June 1, 1991 or had started the legislative process to change size and weight restrictions before June 1, 1991.

Current LCV Operation

The first use of LCVs was on turnpikes in the East and Midwest. On the turnpikes, trucks operate as LCVs while on the turnpike and are broken down at staging areas at either end of the turnpike (sometimes at intermediate staging areas). LCVs were first operated on the Indiana Toll Road in 1956, on the New York Thruway and the Massachusetts Turnpike in 1959, on the Ohio and Kansas Turnpikes in 1960, and on the Florida Turnpike in 1968.(15) Each of these organizations has varying operational requirements. Between 1968 and the 1980s, fourteen western states also began permitting the operation of LCVs. Of these western states, Idaho and Montana began permitting LCVs on their highway system first in 1968, Nevada began in 1969, Utah in 1974, and Arizona in 1976. The remaining of the fourteen, Alaska, Colorado, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Washington, and Wyoming, began permitting LCVs on their networks during the 1980s. The last state to begin allowing LCVs to operate on its network was Oklahoma in 1986.

The regulation of LCV dimensions (size and weight) has been a function of regulation promulgated by the state or the turnpike authority permitting LCV operation. Much like the early truck dimension regulation promulgated by states in the first half of the twentieth century, there is little uniformity in permitted LCV dimensions and several states offer unique operating regulations. Tables 1-1 through 1-6 lists permitted cargo carrying unit lengths and maximum gross vehicle weights for all three LCV combinations (Intermediate Doubles, Turnpike Doubles, and Triples) and the highway access permitted in each jurisdiction. These tables were compiled from a number of documents that occasionally provided inconsistent data.(16)(17)(18)(19) It was initially believed that state rules and law regarding maximum dimensions allowed in each jurisdictions would be fairly simple to identify. However, many of the rules and laws require interpretation. For example, some states define gross vehicle weight limits using the bridge formula and govern maximum lengths (either overall length or length of cargo carrying units and axle configurations) as well. In such a case, maximum gross vehicle weight would vary based on the unique configuration of each truck.

One of the LCV states listed, Nebraska, requires all LCVs longer than 65 feet to travel empty and limit their` travel on portions of I-80 west of Omaha. The purpose for Nebraska's permitting LCVs was to allow a manufacturer of trailers to transport trailers out of state. The

General Accounting Office's study of LCV safety found no current LCV permit holders in Nebraska because of the limitations placed on LCV operation.(20)

In addition, several of the organizations (state or turnpike authorities) have additional operational safety requirements, such as, more stringent requirements on the minimum age for LCV operators, weather conditions when operation is allowed, and hours of the day when LCVs are permitted to operate.

The maze of non-uniform dimension regulations reinforces the point that the LCV industry is very heterogenous and faces heterogenous requirements. Some states have viewed their LCV network as principally infrastructure supporting long-distance movements over interstate highways and highways built to high geometric standards. LCV networks that focus on long-distance hauling principally address the Turnpike Double and Triple markets. Although users of Intermediate Doubles will gain from long-distance networks, networks that provide access to a large portion of the non-interstate system to Intermediate Doubles are principally focused on local and regional movements and may even serve the interests of unmanufactured bulk commodity movements where shipments are principally local.

Table 1-1 Length and Gross Vehicle Weight Limits for Intermediate Doubles by Jurisdiction

State	Maximum GVW (in 1,000s of lbs)	Maximum Length of Cargo Carrying Units (in feet)	Route Access and Restrictions
Alaska	111.5	80.5	Access to the entire National Highway Network and to points within five miles
Arizona	111	92	Restricted primarily to points within twenty miles of Arizona's boundaries with an LCV state
Colorado	110	85	Restricted to the majority of Colorado's interstate system
Idaho	105.5	85.5	Access to the entire National Highway Network depending on a vehicle meeting minimum off-tracking standards
Montana	124	85	Access to the entire National Highway Network
Nebraska	95	85	Only on I-80 - double trailers over 65 feet in length may only travel empty
Nevada	114.5	85.5	Access to the entire National Highway Network
North Dakota	105.5	85.5	Access to the entire National Highway Network
Oklahoma	90	92	Interstates, Oklahoma Turnpikes, and several four-lane divided facilities
Oregon	105.5	68	Access to the entire National Highway Network
South Dakota	129	81.5	Access to the entire National Highway Network
Utah	129	88	Access to the entire National Highway Network plus local delivery designated routes

Table 1-2 Length and Gross Vehicle Weight Limits for Intermediate Doubles by Jurisdiction - continued

State	Maximum GVW (in 1,000s of lbs)	Maximum Length Cargo Carrying Units (in feet)	Route Access and Restrictions
Washington	105.5	68	Access to the entire National Highway Network plus most state routes not on the network
Wyoming	101	81	Access to entire National Highway Network
Turnpikes			
Florida Turnpike Authority(346 miles)	147	85.5	Intermediate Doubles must be combined at special staging areas on the right-of-way
Indiana Toll Road Commission (157 miles)	127.5	86	Access provided to points up to 15 miles from toll gates
Kansas Turnpike Authority (236 miles)	116	92	Access provided to points up to 10 miles from toll booth except allowed 20 miles from northeastern toll booth in Kansas City area
Massachusetts Turnpike Authority (131 miles)	127.4	114	Intermediate Doubles must be combined at special staging areas on the right-of-way
New York Thruway Authority (544 miles)	114.5	85.5	Access to Thruway permitted in the area of several major interchanges, generally less than three miles off the facility
Ohio Turnpike Authority (241 miles)	90	80	Intermediate Doubles must be combined at special staging areas on the right-of-way

Table 1-3 Length and Gross Vehicle Weight Limits for Turnpike Doubles by Jurisdiction

State	Maximum GVW (in 1,000s of lbs)	Maximum Length of Cargo Carrying Units (in feet)	Route Access and Restrictions
Alaska	135	90	Access to the entire National Highway Network and to points within five miles
Arizona	111	95	Restricted primarily to points within twenty miles of Arizona's boundaries with an LCV state
Colorado	110	95	Restricted to the majority of Colorado's interstate system
Idaho	105.5	95	Access to the entire National Highway Network depending on a vehicle meeting minimum off-tracking standard
Montana	124	93	Access to the entire National Highway Network
Nebraska	na	95	Only on I-80 - double trailers over 65 feet in length may only travel empty
Nevada	129	95	Access to the entire National Highway Network
North Dakota	105.5	103	Access to the entire National Highway Network
Oklahoma	90	123	Interstates, Oklahoma Turnpikes, and several four-lane divided facilities
Oregon	-	-	Turnpike Doubles are not allowed
South Dakota	129	100	Access to the entire National Highway Network
Utah	129	94	Access to the entire National Highway Network plus local delivery designated routes

Table 1-4 Length and Gross Vehicle Weight Limits for Turnpike Doubles by Jurisdiction - continued

State	Maximum GVW (in 1,000s of lbs)	Maximum Length of Cargo Carrying Units (in feet)	Route Access and Restrictions
Washington	-	-	Turnpike Doubles not allowed
Wyoming	101	81	Access to entire National Highway Network
Turnpikes			
Florida Turnpike Authority(346 miles)	147	106	Turnpike Doubles must be combined at special staging areas on the right-of-way
Indiana Toll Road Commission (157 miles)	127.5	106	Access provided to points up to 15 miles from toll gates
Kansas Turnpike Authority (236 miles)	120	109	Access provided to points up to 10 miles from toll booth except allowed 20 miles from northeastern toll booth in Kansas City area
Massachusetts Turnpike Authority (131 miles)	127.4	114	Intermediate Doubles must be combined at special staging areas, on the right-of-way
New York Thruway Authority (544 miles)	143	102	Access to Thruway permitted in the area of several major interchanges, generally less than three miles off the facility
Ohio Turnpike Authority (241 miles)	127.4	102	Turnpike Doubles must be combined at special staging areas on the right-of-way

Table 1-5 Length and Gross Vehicle Weight Limits for Triples by Jurisdiction

State	Maximum GVW (in 1,000s of lbs)	Maximum Length of Cargo Carrying Units (in feet)	Route Access and Restrictions
Alaska	135	110	Triples are allowed to operate on the National Highway System and experimental use is allowed on state highways
Arizona	123.5	95	Restricted primarily to points within twenty miles of Arizona's boundaries with an LCV state
Colorado	110	95	Restricted to the majority of Colorado's interstate system
Idaho	105.5	105	Access to the entire National Highway Network depending on a vehicle meeting minimum off-tracking standard
Montana	131.06	100	Access to interstate highways and local access within two miles of an interstate highway
Nebraska	na	95	Only on I-80 - triples may only travel empty
Nevada	129	95	Access to the entire National Highway Network
North Dakota	105.5	100	Access to the entire National Highway Network
Oklahoma	90	95	Interstates, Oklahoma Turnpikes, and several four-lane divided facilities
Oregon	105.5	95	Access to the entire National Highway Network
South Dakota	129	100	Access to the entire National Highway Network
Utah	129	100	Access to the entire National Highway Network plus local delivery designated routes

Table 1-6 Length and Gross Vehicle Weight Limits for Triples by Jurisdiction - continued

State	Maximum GVW (in 1,000s of LBs)	Maximum Length (in feet)	Route Access and Restrictions
Washington	-	-	Triples are not allowed
Wyoming	-	-	Triples are not allowed
Turnpikes			
Florida Turnpike Authority(346 miles)	-	-	Triples are not allowed
Indiana Toll Road Commission (157 miles)	127.4	104.5	Access provided to points up to 15 miles from toll gates
Kansas Turnpike Authority (236 miles)	110	109	Access provided to points up to 10 miles from toll booth except allowed 20 miles from northeastern toll booth in Kansas City area
Massachusetts Turnpike Authority (131 miles)	-	-	Triples are not allowed
New York Thruway Authority (544 miles)	-	-	Triples are not allowed
Ohio Turnpike Authority staging areas (241 miles)	105.5	95	Triples must be combined at special staging areas on the right-of-way

LCV TRAFFIC MARKETS

To better understand the segments of the markets served by LCVs, it is important to understand the cost structure of conventional truck combinations in comparison to LCVs. It may be expect the that the average cost per unit or output (ton-miles or cubic foot-mile) of LCV would be less since they can carry more. This is essentially true for line-haul costs, where transportation is over highways permitting LCVs. However, depending on the type of LCV and the LCV highway network being used, LCVs will have greater fixed costs associated with a trip than a conventional truck making the same trip. For example, a conventional combination carrying a complete truckload will be able to move directly from the origin to the destination. Truckloads being hauled in Turnpike Doubles may require two tractors and two drivers to make the pickup and delivery to and from the staging area at the ends of the LCV highways or for one driver and one tractors to make two trips between the staging area and the destination. Although the Turnpike Double will provide considerable efficiencies during the line-haul portion of the trip, there are additional logistical costs associated with the trip ends. Other logistical costs may be associated with special facilities necessary to load LCVs, special good distribution requirements necessitated by larger loads, special equipment needed to handle LCVs, etc.

To provide an illustration of how the different costs components impact the segment of the market and where LCVs offer a cost advantage, consider a simple example. Suppose a trucking company is examining the economics of moving a balanced flow of several truckloads per week of freight between two points. Also, assume that the freight being carried is of relatively low density and trailers reach their volume limits before their maximum load is governed by gross vehicle weight and axle load limits.

The trucking company first wishes to examine the costs functions for conventional combinations and has the option of serving this market with either 48-foot trailers or 53-foot trailers in relationship to the distance between the origin and the destination. Because the 53-foot trailers can carry more, the costs per ton-mile of goods moved is lower. The average operating costs per ton-mile of a 48-foot trailer and a 53-foot trailer versus trip distance are shown in Figure 1-1. The costs of the combination with the 53-foot tailer will always be lower for several reasons but, most importantly, the 53-foot trailer will make fewer trips.

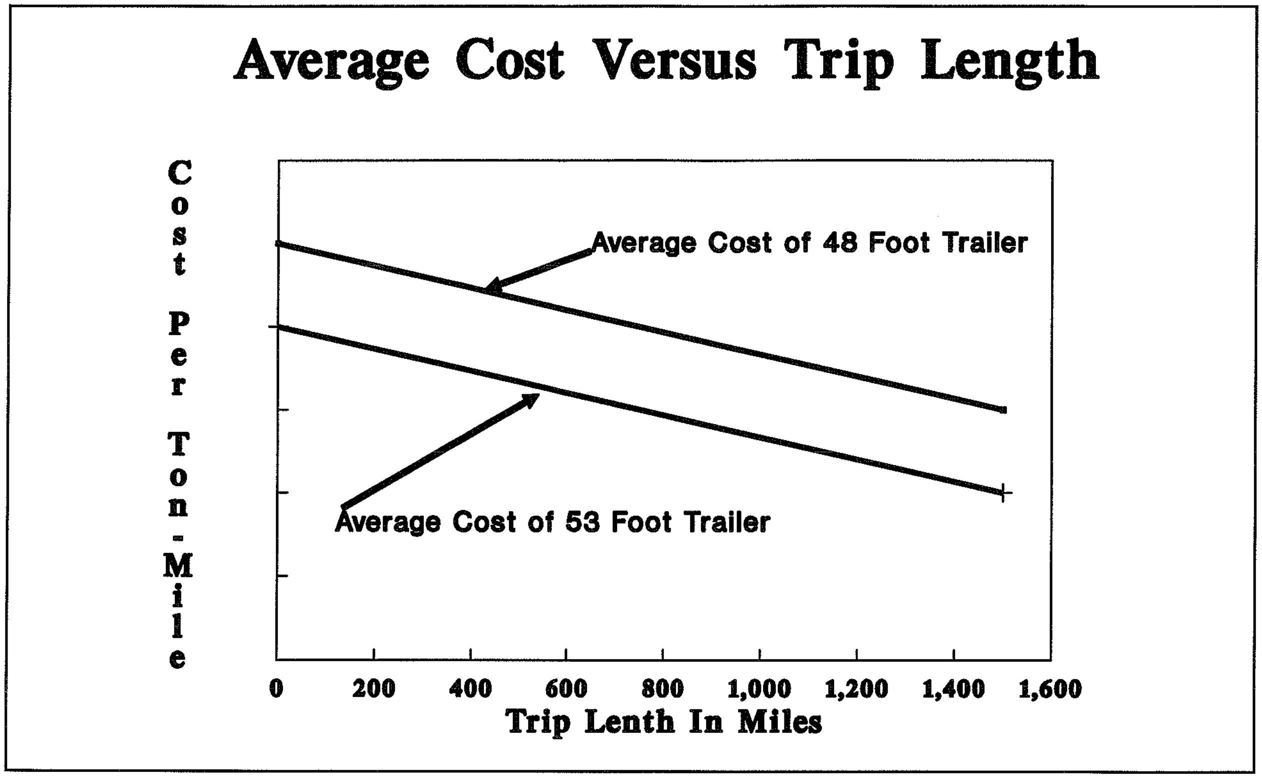

Figure 1-1 Hypothetical Average Operating Cost Function for 48-Foot Trailer Versus 53-Foot Trailer

Shown in Figure 1-2 is the same comparison for an LCV and a conventional combination. For very short trips, a high portion of the average operating costs are associated with LCV logistics costs. The high fixed logistics costs may make an LCV a much more expensive option for short trips. However, as trips become longer, the logistics costs become a smaller portion of the average operating costs and LCV costs drop below those of a conventional combination.

The distance in Figure 1-2 where the average costs of using an LCV drops below the cost of a conventional truck depends on a myriad of attributes. For example, Intermediate Doubles hauling agricultural commodities on a network that includes all highways may incur relatively insignificant logistics costs. In this case, Intermediate Doubles may be less expensive than conventional combinations at all distances. On the other hand, in light traffic

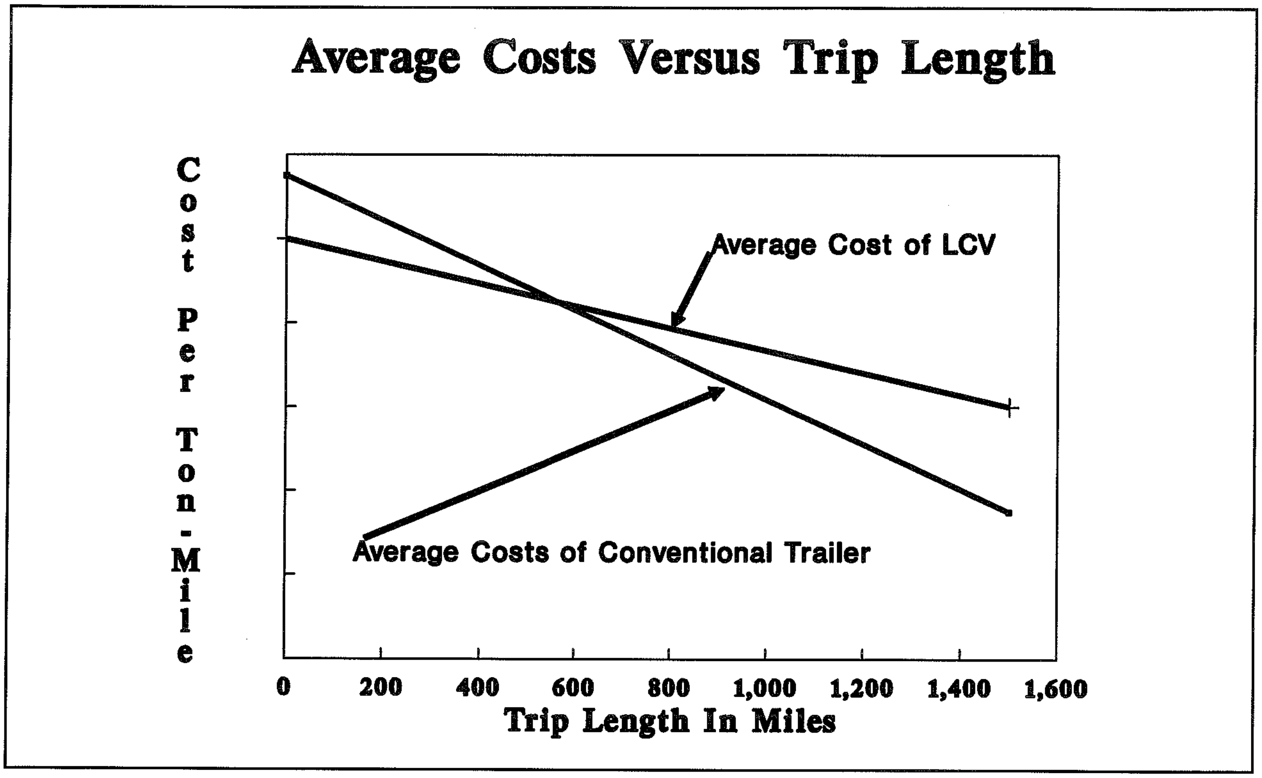

Figure 1-2 Hypothetical Average Operating Cost Function for LCV Versus Conventional Combination

density corridors, the logistics costs of aggregating a load able to fill an Intermediate Double may be too costly regardless of the trip distance. Some of the factors that impact the relative economics of a conventional combination versus an LCV include:

- The traffic density of the corridor. Corridors that have high traffic densities for a carrier are likely to be attractive segments for LCVs.

- The loading and unloading costs associated with the commodity. For example, loading and unloading of field crops into intermediate doubles with open hopper trailers where the trucks are permitted to run on land access highways to the storage facilities (grain elevators) or processing facilities will have negligible logistic costs. On the other hand, where it is necessary to use a staging facility to gain access to the LCV network, the logistics costs may be significant.

- The value and perishability of the commodity. High value or perishable commodities are likely to require high quality and direct transportation services. Delays caused by gaining access to the LCV network or by forming an LCV are likely to cause a disincentive to the use of LCVs for high value or perishable commodities.

- Connectivity of origins and destinations through the LCV network. Regardless of the relative efficiency of LCVs, the LCV network must provide complete or partial access between origin and destination points to be of value to the motor carrier.

Whether an LCV or a conventional truck is more efficient depends on several variables, but principally on the characteristics of demand for truck transportation, the demand for the services of the particular carrier examining the potential use of a LCV, the configuration of the LCV network, and the types of vehicle dimensions permitted on the LCV network. Tables 1-1 through 1-6 clearly illustrate that there is little commonality between jurisdictions in their LCV networks and the vehicle configuration they permit.

TRUCKING PRODUCTIVITY GAINS

Most of the productivity gains in the trucking industry until the 1980s have resulted from increases in truck size and weight. The most common semitrailer length before 1945 was 25 feet, in the early 1950s it was 30 feet, and in the late 1960s and early 1970s it grew to 40 feet.(21) The STAA of 1982 increased productivity by setting minimum trailers lengths to 48 feet and increasing minimum trailer widths to 102 inches. However, because federal dimension legislation permits states to establish longer maximum lengths, many states allow 53-foot trailers. During the late 1970s and early 1980s, the most common semitrailer length grew to 45 feet and, from 1984 until the present, the most common semitrailer length is 48 feet. However, in 1992 (the most recent data available) nearly as many 53-foot trailers were sold as 48-foot trailers.(22)

While truck trailers were growing in size, incremental productivity gains were made through stronger and lighter weight packaging which allowed motor carriers to haul more of a commodity within the confines of a trailer. Also, manufacturers were making goods with lighter weight materials, thereby allowing motor carriers to haul more goods within a trailer before exceeding weight limits. However, Figure 1-3 clearly illustrates the widespread growth in allowable truck weights which have translated to corresponding productivity increases of semi-tractor truck transportation services.(23) Loaded vehicle gross weights increased consistently between 1925 and 1980, resulting in dramatic productivity gains. However, allowable truck weights have been effectively frozen since 1982, bringing about the argument that increases in motor carrier productivity will require additional relaxation of truck size and weight restrictions and the promotion of an LCV network.

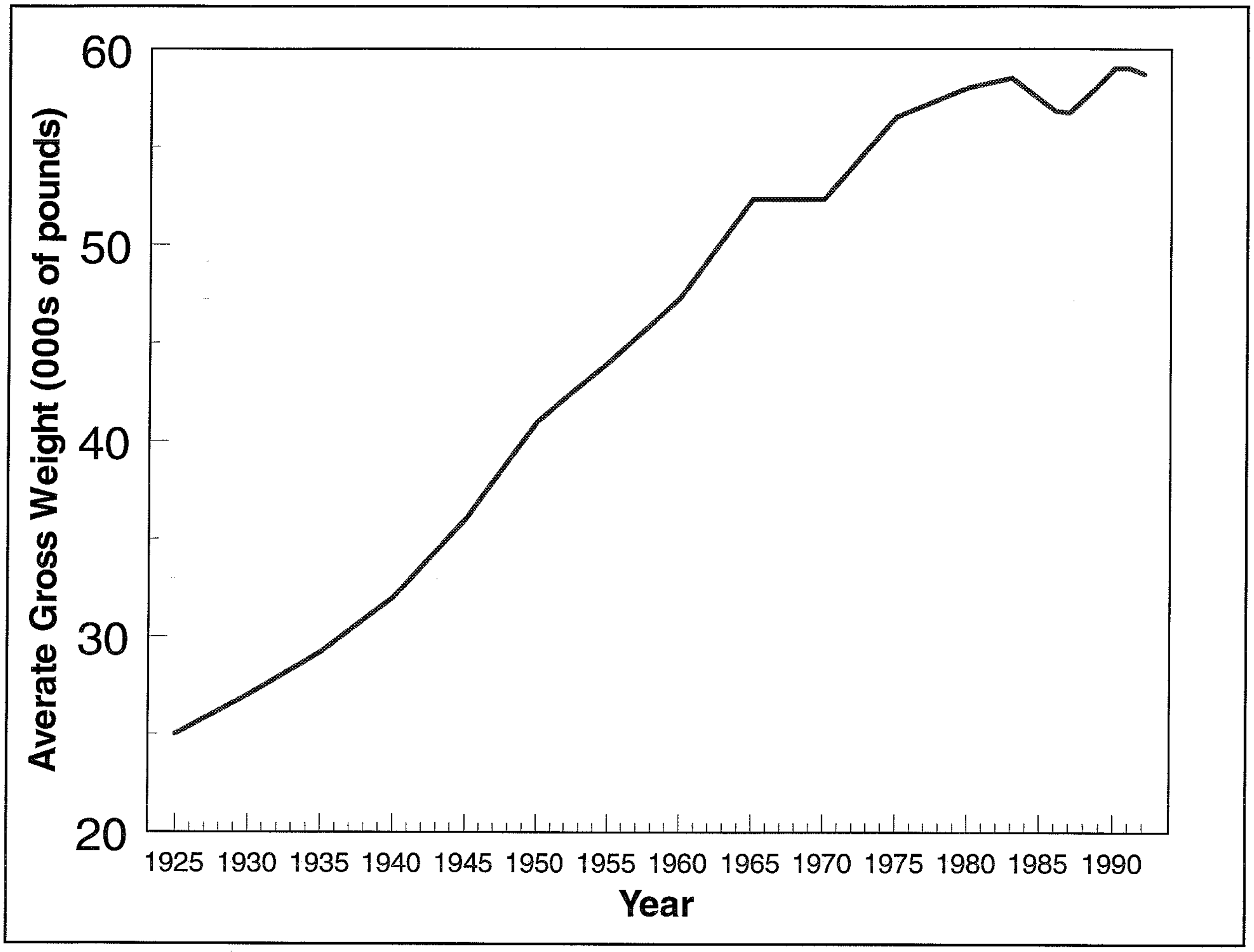

Figure 1-3 Average Gross Weight of Loaded Combination Trucks (23)

Interestingly, in the period between 1980 and 1992, the trucking industry has made significant productivity improvements without an increase in size and/or weight. In the period between 1980 and 1991, the portion of the total U.S. intercity freight expenditures accounted for by truck transportation rose from 72.7 percent to 77.4 percent.(24) Over the same period, expenditures on truck transportation services, as a portion of the gross national product, declined from 5.76 percent to 4.87 percent, a decline of 15 percent. During the same period, total domestic freight expenditures on all modes declined from 7.93 percent to 6.3 percent of gross national product.

The reduction in relative costs of freight transportation services is commonly attributed to the relaxation of economic regulations of the air carrier industry in 1978 and the motor carrier and railroad industries in 1980.(25) Even greater productivity improvements in logistics costs have been attributed to regulatory relaxation. Economic deregulation has resulted in more flexible transportation services, providing transportation service buyers with a continuum of service options. In many cases improved and flexible transportation services have resulted in reduced inventory and holding costs (logistics costs). During the 1980s, total transportation expenditures as a portion of gross national product declined by 1.3 percent. In 1989 alone, inventory costs declined from roughly 5.2 percent of gross national product to 4.4 percent.(26) Over the entire deregulatory period of the 1980s, total logistics and transportation costs declined from a high of 14.7 percent of gross domestic product in 1981 to 11.1 percent of gross domestic product in 1989.

During the 1980s, relaxation of economic regulation squeezed additional productivity from the truck transportation system. Likewise, the transportation flexibility allowed by regulatory relaxation has allowed logistic innovation to further increase productivity. Without further exogenous change (e.g., further deregulation size and weight limits or a technological breakthrough in internal combustion engine efficiency) it appears that further productivity gains may be limited. Hence economic pressures for greater productivity lead to the argument to relax limits on LCVs and allow productivity to increase.

Many trucking trade publications contain anecdotal evidence of trucking companies that report reductions in costs when they replace conventional equipment with LCVs. In support of this anecdotal evidence, estimates of LCV costs indicate significant savings are possible. These costs comparisons only consider line haul costs because trip end costs will vary from load to load. LCVs have distinct cost advantages when considering the line-haul portion of a trip (trips where the origin and destination points have access to an LCV network and therefore are entirely line-haul). The relative cost estimates from a Transportation Research Board study of larger trucks are shown in Table 1-7.(27) The results are general findings and based on average loads. The relative costs are indexed to an 80,000 conventional combination. Although the LCV combinations shown greater costs per truck-mile, they are much more productive than conventional combinations on a ton-mile basis.

Other studies of relative cost report even greater savings. In absolute dollars, an LCV study conducted for Congress by the Federal Highway Administration compared conventional trailers and Turnpike Doubles and found Turnpike Doubles have a 0.367 dollars per mile cost reduction when carrying general commodities.(28) An Association of American Railroads study estimated the average line haul cost of a conventional tractor and 48-foot semitrailer combination to be 0.93 dollars per vehicle-mile and the costs of twin 48-foot Turnpike Double of between 1.20 dollars and 1.24 dollars per vehicle-mile, but because Turnpike Doubles carry much more freight per mile, they delivered a cost reduction of 33 to 37 percent per ton-mile.(29) Another study by Transmode (a Washington, D.C., transportation consultant) compared conventional trailers and Turnpike Doubles and found Turnpike Doubles had a 0.405 dollars per mile cost advantage.(30) Regardless of the specific costs estimate used, it is clear that LCVs can provide significant line-haul cost savings.

Table 1-7 Relative Cost Comparison to a Five Axle, 80,000 Pound Truck

Line-Haul Comparison of Average Costs To A Five Axle, 80,000 Pound Combination

	Percent per Truck-Mile	Percent per Ton-Mile
80,000 pound single semi trailer combination	100	100
110,000 pound double trailer combination	115	90
130,000 pound double trailer combination	124	76

The argument for relaxing truck size and weight restrictions and promoting an LCV network of some kind has merit and should be forwarded as long as the costs (public or private) are not greater than the productivity gains. The LCV debate hinges on the magnitude of the costs and benefits of expanding the LCV network. The costs are largely related to: 1) the potential for increased accident levels and/or accident severity, 2) possible increases in highway and bridge maintenance costs as a result of more truck traffic (part due to diversion from railroads), and 3) traffic diverted from rail resulting in decreased rail revenues (and profits) causing rail carriers to further withdraw rail services and rail infrastructure. All three of these issues are being intensely debated within the freight transportation industry and are discussed in the following sections.

LCV SAFETY CONSIDERATIONS

LCV opponents seem to have a very compelling argument against LCVs on the basis of safety, yet there has been little definitive information on the issue of LCV safety. The most thorough national truck safety data base is the Fatal Accident Report System (FARS) kept by the National Highway Traffic Safety Administration, U.S. Department of Transportation. This database contains records of only fatal accidents and all fatal accidents are recorded in the database within 30 days of their occurrence. In the FARS database, large trucks are considered to be any truck with a gross vehicle weight rating over 10,000 pounds. Based on FARS data, large trucks have traditionally had accident rates higher than the rate for other vehicles. For example, in 1990 large trucks accounted for three percent of all registered vehicles and seven percent of vehicle miles traveled, but they were involved in eleven percent of all fatal accidents that year.(31) In 1992, of the 4,413 people killed in accidents involving heavy trucks, 78 percent were automobile passengers (including the driver), 8 percent were pedestrians, and 13 percent were passengers in the truck.(32) Some truck accidents involved collisions with fixed objects or other trucks, but when the collision was with an automobile, 98 percent of the time the individuals killed were in the passenger cars.

Because of the size and mass of trucks, truck accidents are more likely to result in fatalities. In 1990, tractor-trailers had a fatal accident rate of 3.9 per 100 million miles, passenger cars had a rate of 2.5 per 100 million miles, and single-unit trucks had a rate of only 1.8 per 100 million miles.(33) LCV opponents argue that if large trucks are over-involved in fatal accidents and larger trucks with more mass cause a greater likelihood of two-vehicle accidents resulting in motorist fatalities, then safety clearly negates any arguments for even larger and more dangerous trucks.(34)

On the other hand, proponents of LCVs argue that safety will improve. Once a truck reaches 15 to 20 times the weight of an automobile, increased weight does not seem to increase accident severity.(35) Since using larger trucks will result in fewer trucks being on the road to haul the same amount of goods, safety may be improved by freight being transported by fewer but heavier trucks.

The empirical research that directly addresses LCVs tends to offer drastically varied results. The predominate difficulty with empirical studies is related to the scarcity of data.

LCVs can only operate on a very small portion of the entire U.S. highway system, and they are mostly restricted to special facilities (interstate highways and toll roads). As a result, it is difficult to make accident rate comparisons to the general truck population and very difficult to derive rates of relative exposure (i.e., total miles traveled by each classification of truck (including LCVs) per fatal accident involving each truck classification). Empirical research on LCV safety can be divided into three types:

- Special experiments conducted by states in an effort to demonstrate the relative safety of LCVs.
- Research conducted on accident databases involving combinations with two or more trailers versus general population of trucks. Because most combinations with two or more trailers are Western Doubles and not LCVs, the researchers must assume that the accident history for Western Doubles is indicative of other multi-trailer combinations.
- Analysis conducted to compare LCV and non-LCV truck accidents within a truck company operating both configurations or paired comparisons between two specific truck fleets.

LCV Experiments. Experiments with LCVs have been reported from the states of California (1972), Nevada (1980), New Mexico (1978), South Dakota (1979), Utah (1975), and Wyoming (1974) as well as the Western Highway Institute (1980) and the U.S. Department of Transportation (1981). These studies of longer combinations found fuel savings, higher productivity, and "at least as good a safety record as standard length trucks."(36) Notable is a major one-year-long test by the Colorado State Department of Highways conducted in response to state legislation concerned with fuel conservation and transportation productivity. Ten carriers completing nearly 5,000 trips hauled 19 million ton-miles over a distance of 1.6 million miles.(37) The test was conducted on Interstate Highways 25, 76, and 70 (east of Denver) and included mileage described as "flat to rolling terrain" and a "mountainous area."(38) The vehicle used for most of the test (90 percent of total miles) was the Rocky Mountain Double, with Triples contributing 9 percent of the total miles and Turnpike Doubles less than 1 percent. Fuel savings of 32 percent were reported for the Rocky Mountain Double compared to using single semis (45-foot trailer); Triples recorded a 37 percent fuel savings over single semis.(39) There were no accidents during the test period (The average accident rate for standard tractor-trailer combinations in

Colorado was 2.22 per million vehicle miles.)(40) The study committee concluded that LCVs can be "cost effective."(41)

The Colorado study included an opinion survey of truck drivers.(42) Drivers were paid 1-1/2 cents per mile over the standard rate, and route selection was based on seniority, resulting in the more experienced drivers participating in the LCV test. Compared to a single 45 or a Western Double, 78 percent of the Rocky Mountain Double drivers said they were as safe; 23 percent of the Triple drivers said they were as safe. Fifty-five percent of the Rocky Mountain Double drivers and 59 percent of the Triples drivers said they had acceptable power for adequate acceleration.

Braking power was judged sufficient by 97 percent and 95 percent of the drivers of Rocky Mountain Doubles and Triples respectively. These ratings were consistent with the Government Accounting Office study that indicated exceptional braking ability of combinations due to more rubber in contact with the road surface relative to vehicle weight.(43)

No comments or complaints from the public were received during or after the test period--the report noted that most of the trips were on interstate highways, avoiding the more congested portions of I-25 in Denver, and most were at night.(44) Some adverse reactions from other traffic, such as being afraid to pass, were noted by 30 percent of the Rocky Mountain Double drivers and 50 percent of the Triples drivers. Abnormal swaying or swerving was observed by 19 percent of the Rocky Mountain Doubles drivers and 73 percent of the Triples drivers. The roads between the terminals and the interstate were problems for 14 percent and 32 percent of the Rocky Mountain Doubles and Triples drivers, respectively.(45)

The Colorado report commented on the environmental concerns of air quality and noise pollution. Exhaust and noise, although more for an LCV than a standard truck, would be decreased overall if the longer trucks meant fewer trucks in total. However, the Colorado authors concluded:

> In actuality, if longer trucks were allowed permanently, they would probably comprise only a small percentage of the total trucks on the road and there would be no noticeable or measurable change in air quality or noise pollution.(46)

Pavement life was also considered, with the conclusion that the reduced magnitude of the axle loading would be less damaging to highways than other legal trucks "when loaded to the same weight."(47) The Rocky Mountain Double was judged to do one-third less damage and the Turnpike Double one-sixth as much damage when compared to a tractor-semitrailer or Western Double because the former combinations distribute the gross weight over more axles than the latter.(48) (United Parcel Service acknowledged the more even weight distribution in its selection of triple 28-foot trailers.(49))

Beginning in 1983, Colorado permitted LCVs (Rocky Mountain Doubles, Turnpike Doubles, and Triples) on 791 miles out of 939 total miles of Interstate highways.(50)

Comparative Accident Studies. There have been several comparative accident studies, primarily where the single trailer combinations are compared with doubles of varying configurations (mostly Western Doubles). The basis of these studies is the assumption that if a truck with two short 28 foot trailers is less safe than single-trailer trucks, than combinations with more trailers or longer trailers are likely to be even less safe. The reason for using Western Doubles as a point of comparison is a result of the difficulty in developing unbiased and comparable statistics for accident rates for LCVs and for the population of traditional trucks.

The predominate statistical difficulty in the development of comparable accident statistics for LCVs and traditional tractor-trailer combinations is estimating comparable exposure rates. Exposure rate is the amount of distance traveled per accident or per fatal accident. To develop reasonable exposure rates, analysts would have to be able to accurately estimate the number of miles traveled by each segment of the combination truck population. Further, to remove bias, the distance traveled (the level of exposure) by each fraction of the trucking population should be on similar highway facilities. For example, accident rates are lower on grade separated facilities built to interstate highway design standards than on non-grade separated facilities. If the miles accumulated per accident for LCVs were traveled on interstate design standard facilities and the miles traveled for non-LCV combinations included non-interstate facilities, the exposure rates would be incomparable.

Little data are presently available to accurately estimate comparable exposure rates of LCVs and conventional combination trucks. Mingo, Esterlitz, and Mingo have even identified in their study that exposure rates for Western Doubles (non-LCV doubles) are suspect.(51) They note that Western Doubles account for less than one-percent of the total population of vehicles. Because this is a very small portion of the total vehicle population, very minor errors in roadway vehicle classification counts or even normal variations in traffic vehicle composition during counts could result in significant errors in estimating the exposure of the small population of Western Doubles.

Studies that have attempted to compare accident rates of Western Doubles with single combination trucks have provided mixed results. Yoo, et al., attempted to compare accident rates for Western Doubles and single tractor-trailers using 1974 California data on fatal and non-fatal accidents.(52) Relative exposure rates were estimated by the researchers by taking classification counts at 15 locations throughout the state. The researchers concluded there is no statistically significant difference in accident rates of Western Doubles and single combinations.

In another California study, Graff and Archuleta studied five years of fatal and non-fatal accident data on 18 highway segments.(53) The authors used specific highway segments to avoid problems in relative exposure rates throughout the entire highway network. The authors found there was no statistically significant difference in accident rates of Western Doubles in comparison to single-trailer combinations.

Other studies have used national databases to make similar comparisons. Chirachavala and O'Day used the Computerized Motor Carrier Accident Reports database.(54) This database was developed from data the Federal Highway Administration requires of motor carriers when they are involved in fatal and non-fatal accidents (reported on Form 50T). The Computerized Motor Carrier Accident Reports have been available since 1973.(55) There is considerable under reporting in this accident database, which is thought to capture only 30 to 60 percent of interstate trucking accidents and a smaller portion of overall truck accidents.(56) Exposure rates for this study were based on the Truck Inventory and Use Survey (TIUS) collected by the United State Bureau of Census as part of the Census of Transportation. The study found no statistically significant difference in the accident rate of single tractor-trailer combinations and double trailer combinations.

Another study by Campbell, Blower, Gattis, and Wolfe used the Trucks Involved in Fatal Accidents (TIFA) database. TIFA is a database developed by the University of Michigan Transportation Research Institute.(57) It augments truck accident data in the National Highway Traffic Safety Administration's Fatal Accident Reporting System (FARS) with accident specific data reported on Federal Highway Administration's Form 50T Reports. However, the University of Michigan is successful in finding matches in FARS and the Form 50T Reports only about one-third of the time.(58)

To gain relative exposure rates, Campbell, et al. used the National Truck Trip Information Survey (NTTIS) compiled in 1985. The NTTIS, like TIFA, was compiled by the University of Michigan. Roughly 4,000 truck operators of medium and large trucks were surveyed on four different days and asked for information on their last 24 hours of operation. The object of the survey was to identify the configuration of vehicles used, the types of road travelled, and the times of day when travel took place. The NTTIS data combined with TIFA accident data from 1980 - 84 were used to develop relative accident rates for single-trailer trucks with multi-trailer trucks (mostly Western Doubles). Campbell, et al. found that multi-trailer trucks had a ten percent higher accident rate than single-trailer trucks.

More recently, a study sponsored by the Association of American Railroads and conducted by Mingo, Esterlitz, and Mingo compared accident rates of single-trailer trucks to multi-trailer trucks.(59) They used state generated estimates of vehicle miles traveled by type of vehicle reported under the Highway Pavement Monitoring System (HPMS) and adjusted by FHWA to develop exposure estimates and FARS data to develop accident rates for multi- and single-trailer trucks. The authors found the fatal accident rate for multi-trailer trucks to be 22 percent higher than single trailer trucks. In additional analysis, the authors used TIFA accident data and HPMS traffic estimates to develop another accident rate. This time multi-trailer trucks were found to have a 47 percent higher accident rate.

Probably the most rigorous truck accident study was sponsored by the Insurance Institute for Highway Safety and conducted by Stein and Jones.(60) The research collected original accident data and control group information. Over a two year period (1984 - 86), accident data were collected in Washington State on Interstate Highway 5 and Interstate Highway 90.

The study design involved officers of the Commercial Vehicle Enforcement Section of the Washington State Patrol. Each accident of a truck over 10,000 pounds was included in the data and all trucks involved in an accident were inspected by an officer who noted any safety related defects, the truck's configuration, and other data related to the truck and the accident. One week following the accident, at the same time of day and at roughly the same location, an officer randomly stopped a truck and performed a complete safety inspection (taking roughly 30 minutes). Immediately after completing the inspection, a second truck was stopped and inspected, followed by yet another truck being stopped and inspected. These three inspections provided data on the relative exposure of single and multi-trailer trucks. By the end of the study, the researchers had 676 truck accidents involving 734 large trucks. Almost 85 percent of these accidents were followed up by this series of random inspections at the actual accident sites.

The data set included 129 and 308 single-trailer combinations involved in single vehicle accidents and multiple vehicle accidents, respectively, and 69 and 73 multi-trailer combinations (this includes both Western Doubles and Intermediate Doubles) involved in single vehicle accidents and multiple vehicle accidents, respectively. Findings indicated that multi-trailer combinations are significantly more likely to be involved in single vehicle accidents and have a significantly higher accident involvement rates. The authors conclude by stating "When the crash involvement of doubles was compared to that of tractor trailers operating under similar conditions, doubles were involved in crashes two to three time more often." The over involvement of doubles was found regardless of driver age, hours the driver had driven prior to the accident, cargo weight, or type of fleet (measured by fleet size). Although the authors may have found elevated accidents for these specific Washington highways, others have cautioned against extrapolating these results and applying them generally across all highways in all locations.(61)

Same Fleet Comparisons. Comparison of accident rates using trucks that have different configurations, have similar maintenance programs, operate over the same routes, and have operators that have received similar safety instructions provides an attractive means of discovering the inherent differences in the safety experiences of single and multi-trailer configuration trucks. Jovanis, Chang, and Zabaneh reported on such a research study using carrier kept accident data.(62) The carriers included in the accident database have well-established safety programs and make good faith efforts to continuously adhere to federal safety standards.

Their data set included "nearly 900 accidents (376 involving singles and 507 doubles) and over 300 million vehicle-miles of operation (127 million by singles and 209 million by doubles)."(63) Accident rates for the years of 1983, 1984, and 1985 were compared on four types of facilities: access-controlled highways, non-access controlled highways, local streets, and parking areas. During this period, new double-trailer combinations were being introduced into the fleet. As the drivers became more adept at driving double trailer combinations, their safety improved during the period of data collection.

Over the three year period, doubles had a statistically significant lower accident rate for all four types of facilities. Overall and on all types of facilities, single accident rates were 2.95 accidents per million vehicle-miles and double accident rates were 2.42 accidents per million vehicle-miles. The authors conclude "the double configuration is generally as safe or safer than the single configuration, even when roadway, traffic, and environmental conditions are specifically controlled."

Interpretations of Safety Research. The findings of safety research on multi-trailer combinations are clearly ambiguous. Scholarly research has been conducted on similar or the same databases and provided opposing results. In their 1986 "Twin Trailer Trucks" report, the Transportation Research Board found that the three most reliable studies of the day (several of the studies reported here have been completed since then) showed that doubles have seven percent lower, five percent higher, and twenty percent higher fatality rates than singles.(64) The Transportation Research Board report concludes that accident rates for Western Doubles (twin trailers) are equal to or slightly higher than those of singles per vehicle mile and generally lower than those of singles per ton-mile.

Because of the lack of definitive safety results for Western Doubles, it is even more unclear what the prospective safety implications are for LCVs (longer double and triple combinations). In the General Accounting Office's study of LCV safety for Congress, they conclude "that until shortcomings of existing databases can be overcome, the actual impacts all types of LCVs have on highway safety will be unknown."(65) The General Accounting

Office goes on to recommend improvements in tracking accident and travel data, especially related to the reporting of non-fatal accidents.

Highway and Bridge Costs[4]. Highway damage is due to axle loading induced fatigue and is generally a function of the number of Equivalent Single Axle Loads (ESALs) sustained by a pavement. ESAL calculations are based on both the weight of the axle loading and the response of the subject material to loading. ESALs are intended to express the loads sustained by a pavement as a function of a standard 18,000 pound axle load. For example, a 20,000 pound axle load is more than one ESAL (18,000 pound load) and a 16,000 pound axle load is less than one ESAL. The amount more or less than one is dependent on the response of the pavement material to the load. Therefore, a concrete pavement of a given thickness will experience a different number of ESALs for a given load (e.g., 20,000 pounds) than will an asphalt pavement of the same thickness.

Bridge damage is a function of the overall load placed on a bridge. Thus, while fatigue and damage to pavements can be reduced by spreading the load over more axles, stress on bridges is a function of gross vehicle weight. Bridge designs and bridges are effected more by the maximum loads expected and sustained rather than by repetitive loads like pavements. Bridge strength is calculated to accommodate a design vehicle that could be served indefinitely. Existing bridges may be overstressed by the greater gross weight of LCVs and thus their use by LCVs may be restricted.

Because LCVs can carry more, fewer trucks will be required to haul the same amount of goods. Moody, for example, in his forecasts of LCV traffic, estimated that when freight is moved by Turnpike Doubles as opposed to conventional tractor trailer combinations, it will require, on the average, 64 percent fewer miles traveled and when goods are moved by triple trailer combination 72 percent fewer miles traveled.(66) In a simplistic sense, because loads in a LCV are spread across more axles and fewer trips are made, several studies have estimated that actual pavement maintenance costs may remain the same or decrease as a result of increased use of LCVs.(67)(68)(69)

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[4] Infrastructure costs are a concern of the companion project being conducted at the University of Iowa. Therefore, only cursory coverage of the infrastructure costs issue is provided in this document.

All forecasts of bridge costs under an LCV network scenario show increased costs because the stress placed on bridges is a function of the maximum load and not the distribution of loads.(70)(71) Because some traffic will be diverted from the railroads to LCVs and LCVs may carry greater loads than conventional trucks, bridges will receive greater loads. As a result, some bridges that are not currently structurally deficient will become deficient in the face of greater loads. The extent of increased bridge costs are unclear.

The Transportation Research Board's 1990 increased estimates for bridge replacement and maintenance costs due to increases in size and weight were based on a survey of all state transportation departments to determine the value the state would use to determine the safe stress level on bridges within its jurisdiction.(72) AASTHO's "Manual for Maintenance Inspection of Highway Bridges" defines two levels of safety factors for calculating the maximum stress for bridges--the operational stress level and the inventory stress level.(73) The "operational stress level" allows loads that are 75 percent of the over stress limit, and the "inventory stress limit" allows loads 55 percent over stress limit. The operational stress level allows heavier loadings and is used when calculating the maximum for special heavy loads on an infrequent permitting basis and for posting of load-limited deficient bridges. The inventory limit is used for determining maximum loads allowable on a routine basis. In the Transportation Research Board study, roughly half the states responding to the survey stated they would use the operating limit (the higher load limit) when evaluating bridges to become part of an LCV network and 16 percent would use the inventory stress limit. Two years later in a similar survey the results were nearly opposite, only 20 percent said they would use the operating limit and 58 percent stated that they would use the inventory limit (the lower load limit).(74) The change in the states' maximum load limits determinations is attributed to state engineers becoming more familiar with LCV proposals. The change in the limits significantly increases the number of deficient bridges.

Even though the potential increase in bridge damage is unclear, it is unlikely the estimated annual cost increases will counter the much larger increases in transportation productivity that result from providing an LCV network. However, the annualized bridge construction and improvement costs may not be the issue. Instead, the problematic issue will most likely be the marginal capital cost of one-time capital improvements. Similar to the one-time capital improvements are other necessary improvements to highway geometry, particularly at interchange ramps, and the construction of staging facilities. For example, an AASTHO survey of state agencies, with 46 states responding, found only 43 percent of the interstate interchanges could safely accommodate Triples, 34 percent could accommodate Intermediate Doubles, and 25 percent could accommodate Turnpike Doubles.(75) The one-time costs (incremental costs) associated with making the improvements necessary to accommodate LCVs are likely to be significant and states may have difficulty in generating enough funds to sustain the incremental costs of LCV network expansion. Hence, the financial problems for highway agencies if the LCV network is expanded may not be the long-term average costs of the improvements, but rather the incremental capital costs of the necessary bridge, geometric, and safety improvements.

Traffic Diversion From Rail Due to A National LCV Network. One of the most contentious arguments against allowing the widespread use of LCVs has been the one expressed by the railroad industry. Their argument is that widespread LCV networks would divert a significant and lucrative share of the freight market currently carried by railroads to LCVs. Such a diversion of freight and the resulting loss of revenue would cause irrevocable damage to the railroad industry and result in line abandonments and diminished rail services. For example, the Association of American Railroads (AAR) predicted that railroads would lose nine percent of their volume and 52 percent of their revenue if twin-48s were instituted nationwide.(76) The effect on net operating revenue is an estimated loss of between 40 and 55 percent under such a scenario.(77),(78) The AAR also predicted long-haul truckload carriers using Turnpike Doubles would be able to reduce their per-mile break-even point to between 45 cents and 55 cents per mile, "a productivity level that could bankrupt some railroad lines."(79)

The American Trucking Associations (ATA) has argued the impact on the railroad industry will be much less. The ATA's estimates are about four percent loss in total rail ton-miles and a loss of about 4.6 percent of the railroad gross revenues (note that the AAR figure was for net operating revenues).(80) Although the two industries agree there will be traffic diverted from railroads as a result of a nationwide network for LCVs, the magnitude of the impact on rails varies widely.

Another study by the Massachusetts Institute of Technology predicted railroads' gross revenue loss at 3.9 billion dollars out of a 30 billion dollar total railroad industry gross revenue.(81) Major traffic losses would be in high-value commodity shipments such as motor vehicles, paper, chemicals, lumber, and foodstuffs. Rail would suffer a net revenue loss of 1.7 billion dollars (out of 3.12 billion dollars total net or 1.98 billion dollars net railway operating income). A quarter of the railroads' fast-growing and lucrative intermodal business would be diverted to trucks if Turnpike Doubles operate, reducing the rail share by 4.4 million more trailer loads every year.

Although the magnitude of the diversion is important to individual freight handling companies and shippers, there is no intrinsic reason for protecting the railroads from traffic diversion if, when taking both private and public costs into account, traffic can be more economically transported by LCVs. So long as the motor carriers employing LCVs are charged the marginal public expense of providing highways and bridges for their use, then the transportation system is made more efficient and a net benefit will be realized.

Presumably, states could devise highway use taxes for LCVs equal to the incremental (marginal) highway use cost. However, there is only inconclusive evidence of the safety costs associated with expanded LCV use. Therefore, because the safety consequence and safety cost of more widespread use of LCVs is unknown, it is impossible to determine if the economic benefits exceed the costs of expanded LCV use.

Local Levels of Diversion From Rail. On a local level, diversion of traffic to LCVs is highly dependent on the types of commodities shipped locally and the LCV network. Intermediate Doubles, for example, are very effective vehicles for hauling bulk commodities like grains, sugar beets, and potatoes. However, if access in Iowa were restricted to interstate highways and LCVs could only be assembled at staging facilities on interstate right-of-ways, the LCV network would be of little use to movements of agricultural commodities from farms and rural elevators to processing facilities or to Mississippi River terminals. On the other hand, if Intermediate Doubles were widely allowed on Iowa highways, grain movement to Mississippi River terminals and processing facilities would be diverted to

LCVs. This would threaten the existence of several of the state's grain hauling regional and shortline railroads and light density branch lines.

FUTURE STATE LEVEL LCV POLICY ISSUES

Although the Intermodal Surface Transportation Efficiency Act of 1991 provided a temporary hiatus in the debate of the expansion of use of LCVs, Iowa and other non-LCV states are apt to receive continuing pressure to expand the use of LCVs in the future. The completion of the FHWA road test, as required by ISTEA, will once again place the debate over LCVs on the national transportation agenda.

When the LCV debate reopens, the motor carrier industry will once again seek to broaden the use of LCVs and continue to seek additional productivity gains resulting from the use of LCVs. Shippers can also be expected to support expansion of the LCV network. For example, in a recent Midwest Transportation Center research project, a questionnaire was sent to 234 Iowa shippers.(82) Roughly 65 percent of the shippers surveyed agreed with the statement that "significant savings are possible with longer combinations vehicles."

Another issue that will reopen the size and weight debate is the North America Free Trade Agreement (NAFTA). The three parties to the agreement, Mexico, the United States, and Canada, all have different truck size and weight limits.(83) In the United States, single tractor-trailer combinations have five axles, are limited to 80,000 pounds gross vehicle weight, and allowed 48- to 53-foot trailers (45 states allow 53 foot). In Mexico, the most common heavy-duty commercial truck is a six-axle combination limited to gross vehicle weight of 90,000 pounds with a maximum length of 48 feet. In Canada, the maximum axle combination load is 137,800 pounds and only half of the provinces allow 53 foot trailers. NAFTA calls for a three year trilateral review to study the truck weight and size issue to promote greater harmonization between the three countries. Although the size and weight issues addressed by NAFTA are not entirely related to LCVs, NAFTA does reopen the truck size and weight debate.

States, like Iowa, that may in the future contemplate allowing the use of LCVs on their highways will need to examine the costs versus the benefits of LCVs. With the exception of safety, past research has generally found that LCVs provide a net benefit. Safety costs and benefits of LCVs are still uncertain. The impacts, however, will be largely a function of the operating networks regulation in the state and its connection and uniformity with LCV networks and regulations in other states. Design decisions that may have profound effects on the use and impacts of LCVs include:

- The vehicle configurations and dimensions (size and weight) allowed to operate on the LCV network.
- The extent and coverage of the state and adjacent states by the network.
- The access provided to the network, e.g. allowing trucks to travel off the network for access or requiring staging facilities on the LCV network.
- Safety restrictions related to equipment, the qualifications of the driver, and operating constraints dependent on the time of day or weather conditions.

These and other decisions should be made in close cooperation with other states in the region and in conformance with national size and weight uniformity activities. The importance of compatibility with adjacent states is illustrated by the high volume of truck traffic between Iowa and its neighboring states. For example, over 60 percent of the interstate truck freight that originates in Iowa is destined to a neighboring state.[5] If Kansas is included as a destination, the traffic jumps up to nearly 70 percent. In other words, it is much more important that Iowa conforms with nearby states, like Nebraska, Missouri, and Illinois, accounting for 16.1 percent, 13.5 percent, and 13.1 percent of Iowa originating truck freight, respectively, than more distant destinations.

The remainder of this report provides additional background information to promote a better understanding of the LCVs and potential LCV traffic in Iowa. The next chapter summarizes the results of a survey of trucking firms that currently operate LCVs. The third chapter investigates freight traffic generated in Iowa and carried across the state. The last chapter summarizes the findings of this report and identifies future research needed to more adequately support the policy debate regarding LCVs.

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Chapter 2
Survey of LCV Permit Holders

While the literature contains estimates of operating costs of Longer Combination Vehicles (LCV) and contains forecasts of the prices of freight transportation services if a national network were deployed, it contains little information on existing LCV services in jurisdictions already permitting LCVs. The researchers believed if they could gain information on the current prices paid for services through the administration of a survey of LCV permit holder, this information could be extrapolated forward to better understand changes in costs as a result of a more widespread LCV network. Although these aspirations are logical, they proved optimistic.

If nothing else, it has been surmised that comparisons of cost per ton-mile or cost per trailer or container mile may over simplify the transportation market. Clearly the most significant impact of a more widespread LCV network is the expansion of flexibility of motor carriers to provide services using tractor-trailer operating strategies not currently available. To illustrate, when the survey asked for prices of LCV services, one trucking company that operates Rocky Mountain Doubles appeared confused. For routes between points where Rocky Mountain Doubles are permitted, the carrier had the choice of dispatching a tractor with one 48 foot semi-trailer or a tractor with a 48 foot semi-trailer and a 26.5 foot trailer. The decision is based on which combination would most efficiently accommodate the current traffic. Regardless of whether the shipper's freight is carried in a truck with a single semi-trailer or in a double, the shipper pays the same price. Ultimately the ability to carry freight in an LCV may result in lower costs of truck services but, the immediate benefit for this particular carrier is more flexibility which results in more efficient allocation of equipment resources. This example illustrates that a simple comparison of the prices of LCV services to non-LCV services and speculation of what the future may hold under an environment where the LCV network is expanded, oversimplifies what is a very complex and dynamic market.

This chapter discusses the results of a questionnaire administered to LCV permit holders. The questionnaire results are more descriptive of LCV operators in general than able to provide specific conclusions to forecast LCV operation under an expended network.

QUESTIONNAIRE

A two-page questionnaire (Appendix A) was sent to 104 holders of state-issued LCV permits. The addresses of permit holders were obtained from the public records of states that issue permits for LCVs. These carriers were headquartered in 27 states: Arkansas, California, Colorado, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Maryland, Minnesota, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Texas, Utah, Virginia, Washington, Wisconsin, and Wyoming. The survey was introduced by a personalized letter from the Midwest Transportation Center which described the purpose of the study, and assured respondents of anonymity. A summary of the findings was offered to encourage participation, while a postage-paid return envelope was provided for the respondents' convenience.

Responses from 35 users were received in complete or nearly complete form. The descriptive statistics presented in this chapter should be viewed as general profiles of LCV operators, indicating the types of equipment employed, the types and volumes of commodities carried, and indicators of the price of LCV service.

Carrier Type

Forty-four percent of the respondents were for-hire less-than-truckload (LTL) carriers and 41 percent were for-hire truckload (TL) carriers. Private carriers (owned and operated for the benefit of the shipper) comprised the remaining 15 percent of the sample. LCVs were operated by 91 percent of these firms during the year prior to the survey, indicating that the permits were being exercised by most of the holders.

The carrier type did not affect the tendency to use owner-operators. Regressions of the number of owner-operators versus the percent of freight that was TL, LTL or private; produced R-squared values lower than six percent, showing the lack of a statistical relationship. Thus indicating, in general, carriers of TL, LTL, and private freight are not more or less likely to employ owner-operators.

Size and Make-up of Firms.

The carriers represented in the sample varied in size from 2 to 12,000 full-time employees. The median size was 100. The for-hire LTL carriers using LCVs tended to be the larger firms, although the statistical relationship between LTL freight as a percentage of total shipments and carrier size was weak. When LTL shipments as a percentage of all shipments hauled by the carrier was regressed against the number of employees, an R-squared of 0.24 resulted. Similar regressions of the percentage of LCV shipments carried in truckloads and private versus the number of employees produced even lower values of R-squared, .117 and .035, respectively. It may be concluded that the data did not show a relationship between firm size and activity of carrier (for-hire less-than-truckload, for-hire truckload, or private).

Employees of six (19 percent) of the represented firms are represented by a bargaining unit. The remaining 81 percent are not.

Nearly one-half (47 percent) of these firms worked with owner-operators. There is a wide range of 1 to 975 owner-operators used; the median was 10. Slightly over one-half of the sample did not use owner-operators. A linear regression test of the owner-operators percentage of total employment versus number of employees produced an R-squared of 0.018. This result suggests that the tendency to use owner-operators was not a function of the carrier's size.

Equipment Combinations

Respondents were asked to identify the equipment they used according to the combinations listed below:

- Western Doubles: two 28-foot trailers (really 27.5-foot trailers but referred to as 28-foot trailers) behind a tractor. This combination is not technically an LCV, but was included because it represents a longer combination than a standard single combination vehicle.

- Triples: a tractor and three 27.5 foot trailers.

- Rocky Mountain Doubles: a tractor and 40 to 48-foot trailer pulling a 27.5-foot trailer.

- Turnpike Doubles: a tractor pulling two 48-foot (or 45-foot) trailers.

- Straight truck plus 27.5-foot trailer.

- Bulk product trailers - intermediate doubles.

As shown in Figure 2-1, respondents showed experience with a wide variety of combinations, with 28-foot trailers being mentioned more than longer trailers and bulk product trailers.

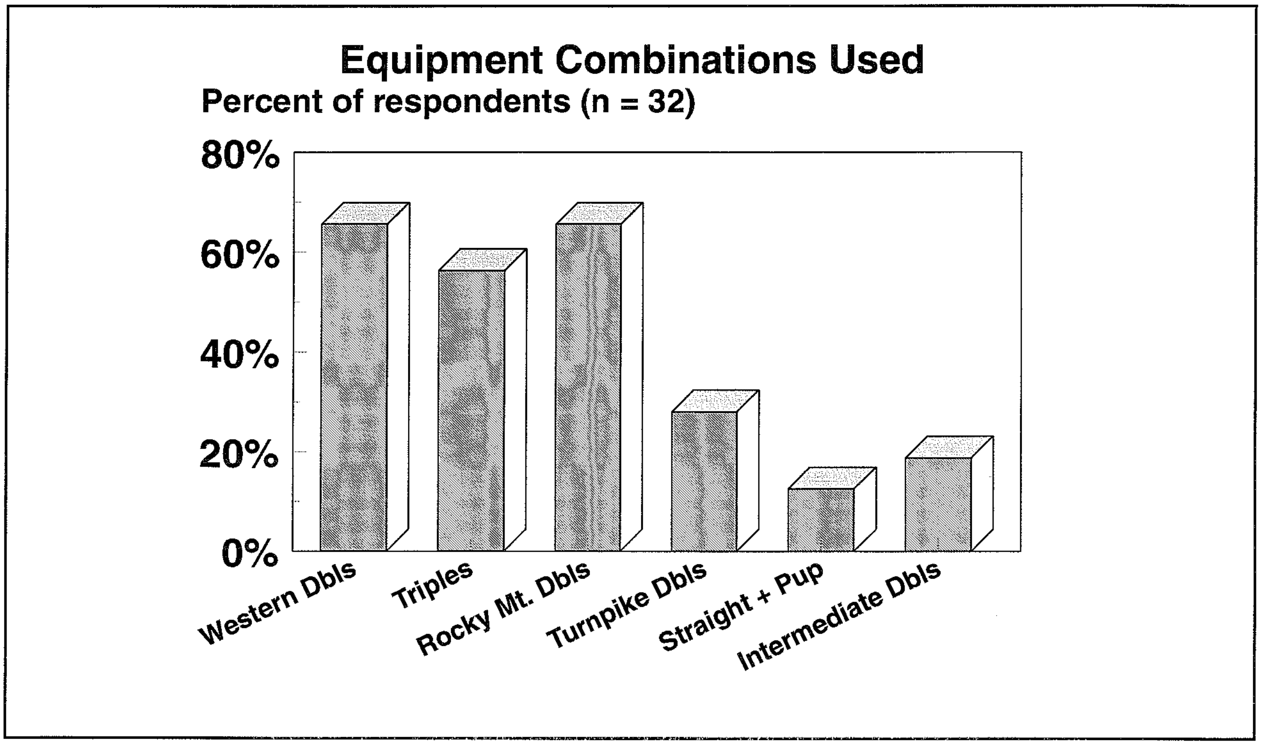

Figure 2-1 Type of Equipment Used By Carriers

Commodities carried in LCVs. The respondents were asked to identify the general categories of commodities they most frequently hauled in LCVs. What could have been an extensive list actually contained a limited number of discrete categories, mainly general freight (as would be expected from the LTL carriers, if not the others). The list of commodities is shown in Table 2-1.

The respondents more often than not answered "general commodities," which is mainly packaged freight with a wide variety of specific items. For further classification, three products groups were used: general commodities, petroleum, and other. Cross-tabulations of the commodity groupings with firm size produced a Chi-square value of 4.686, suggesting statistical significant differences (at the .10 level) in the sizes of firms carrying each of the three commodity groups. These data thus suggest general commodities were more likely to

Table 2-1 Commodities Carried by Respondents

Commodities	Number of respondents
Agriculture, Forrest, Compost	1
Food, Related Products	1
Retail Apparel	1
Petroleum, Crude Oil, etc.	6
Construction Material, Rock, Gravel, etc.	2
Hazardous Waste, Construction Material	1
General Commodities	18
Unknown	2
Total	32

be carried by the larger firms, while the smaller firms handled products classified as petroleum and "other." This conclusion is also consistent with the comparison of commodities carried on LCVs and the TL or LTL classification, which demonstrated strong differences in carrier size (Chi-square of 14.454, showing differences significant at the .001 level). For example, the petroleum and other products were always carried in truckloads. All the LTL freight was classified as general commodities. This conclusion, while not unexpected, does provide one indication of the validity of the collected data.

When asked "in what volumes are these commodities most often carried," responses were split. Forty-four percent indicated in less-than-truckload quantities and 41 percent answered truckloads; the remaining 15 percent were private carriers as shown in Figure 2-2. While the bulk products might be expected in truckload quantities, some general commodities were also carried in larger volumes.

Rates

The carriers were asked to furnish rates for typical commodities and volumes carried between their most frequent origin and destination pairs. Sometimes the responses were in the dollars per hundredweight, and others were in dollars per mile. Some were flat rates per

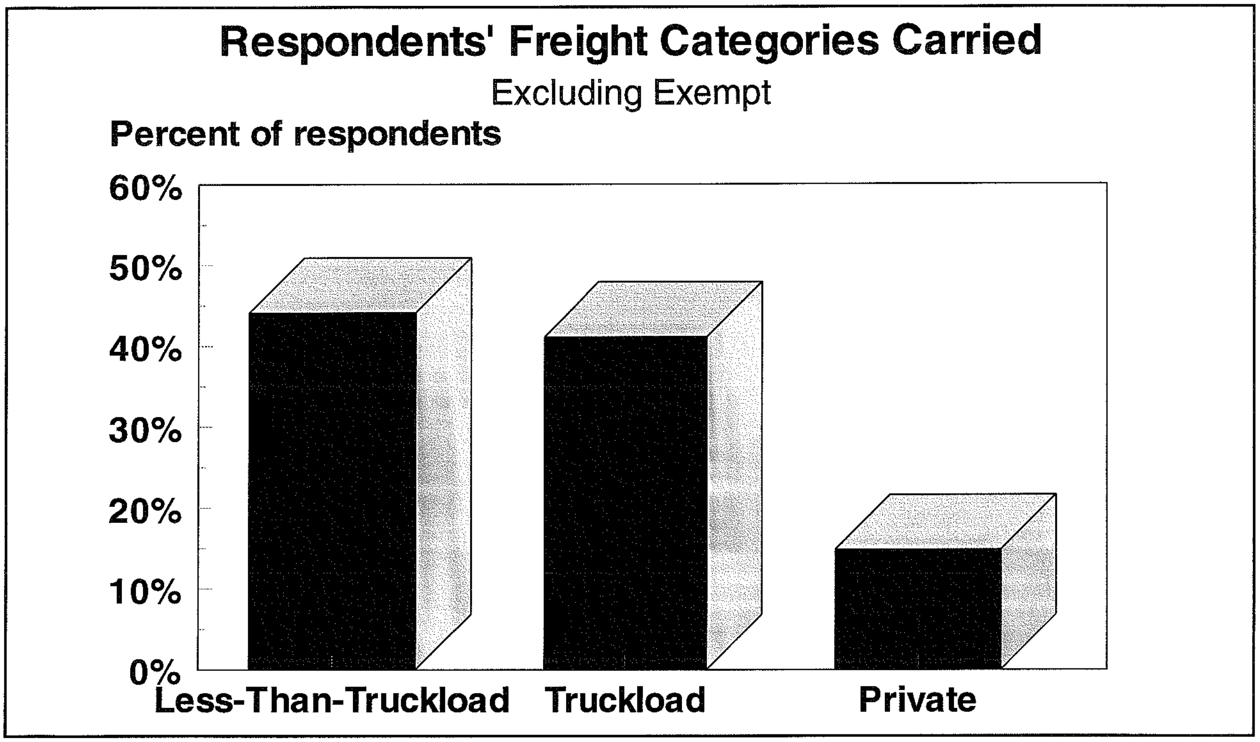

Figure 2-2 Percent of Freight Carrier by Category Excluding Exempt

trip. For comparison, the pricing terms were converted to rates per hundredweight, and rates per ton-mile, using a mileage atlas. The potential relationship of rates to distance could thus be observed. "General commodities" was the category most often described (with 18 responses). These responses are graphed three ways: rates per hundredweight versus distance, rates per ton-mile versus distance, and dollars per ton-miles versus distance. Distances ranged from 105 miles to 2,152 miles; see Figures 2-3, 2-4 and 2-5. When equipment was specified, all but three responses were for 28-foot trailers exclusively (Western Doubles and Triples); the remainder were Rocky Mountain Doubles.

Rates per hundredweight varied between $3.75 and $20.27 and were observed to vary somewhat in proportion to distance. A simple regression of the rates versus distance, as plotted in Figure 2-3, resulted in an R-squared of .845, indicating a strong linear correlation with distance. That is, nearly 85 percent of the variance among rates is explained by the equation based on distance as the independent variable. Dollars per ton-mile versus distance (Figure 2-4) appears to fall at a decreasing rate, from a high of $5.30 to $0.60. The .351

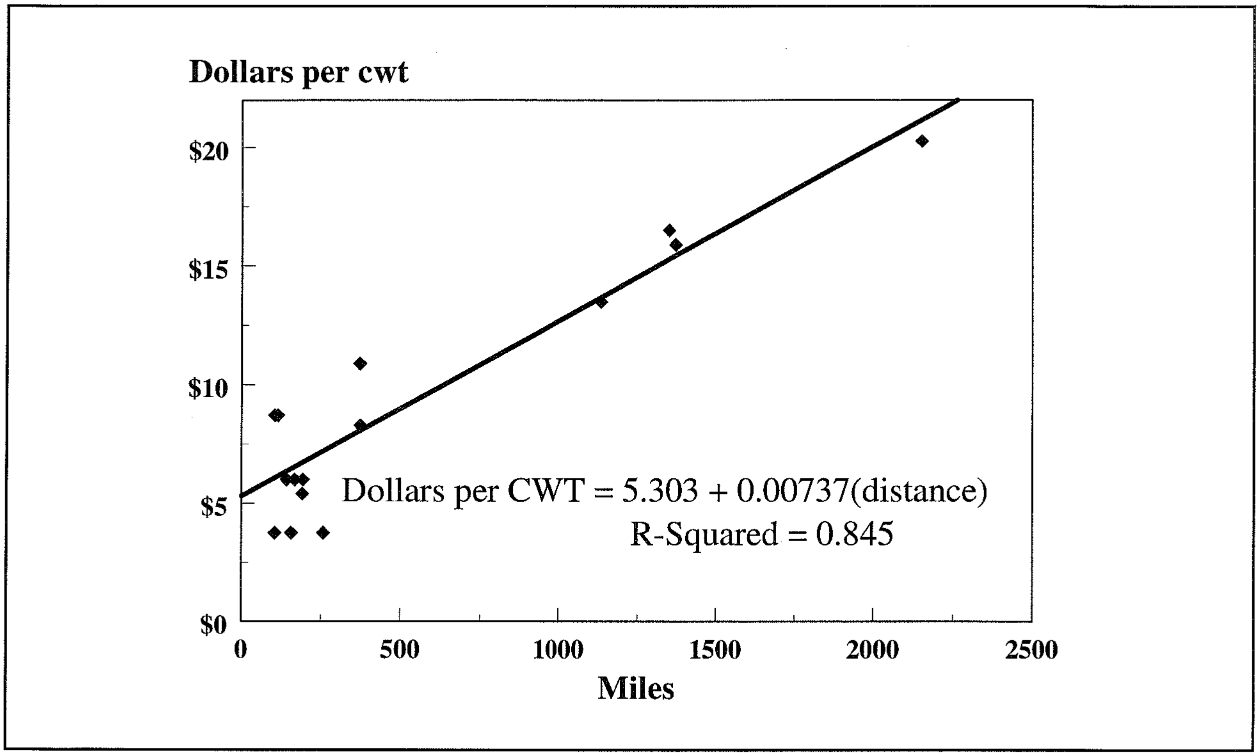

Figure 2-3 Linear Model of Rate, in Dollars per Hundred Weight, Versus Distance

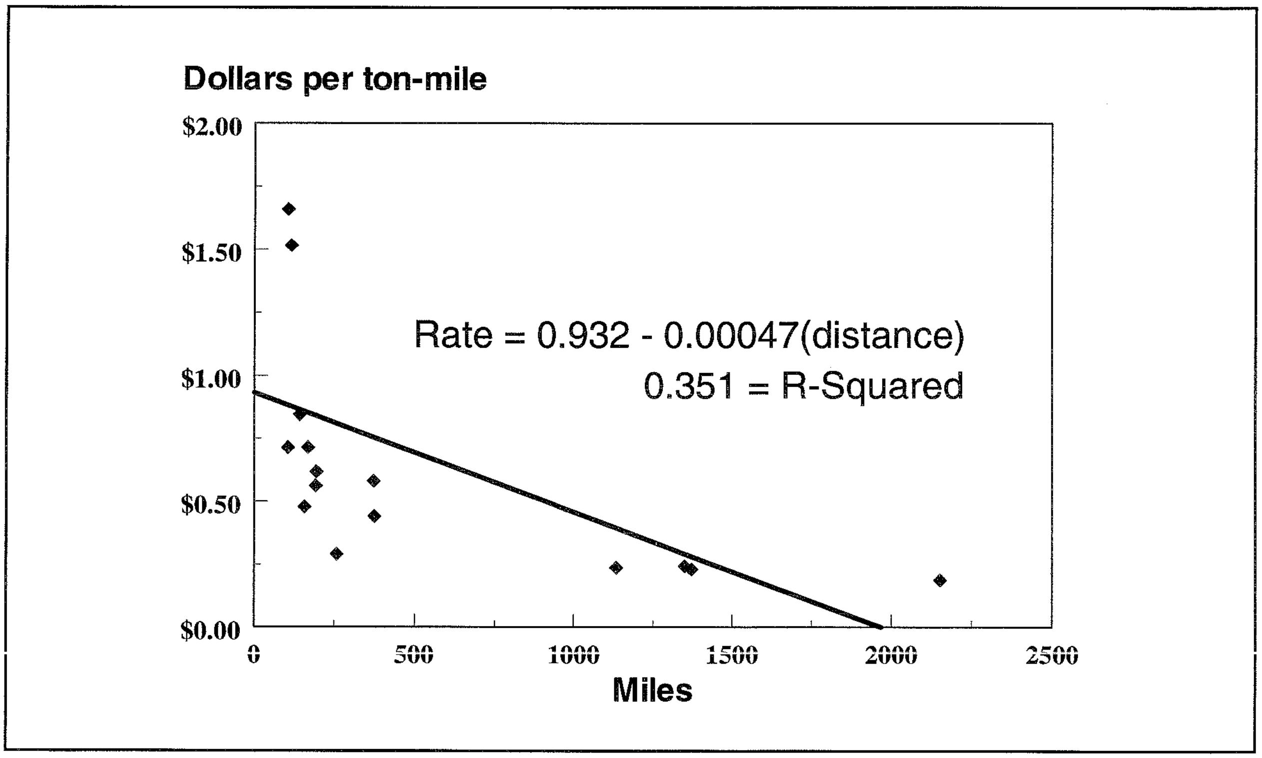

Figure 2-4 Linear Model of Rate, in Dollars per Ton-Miles, Versus Distance

R-squared value shows the lack of a linear relationship. Very short trips appear to have high fixed costs. At longer trip lengths, the effect of the fixed cost becomes less significant as the fixed cost is divided over more miles. To better model the data, a multiplicative model is used which explains almost twice as much of the dependent variable variance as the linear model. The multiplicative model is shown in Figure 2-5. The higher R-squared supports the assumption of fixed costs associated with a trip of any length. It is expected that the fixed cost would be especially pronounced with less-than-truckload freight.

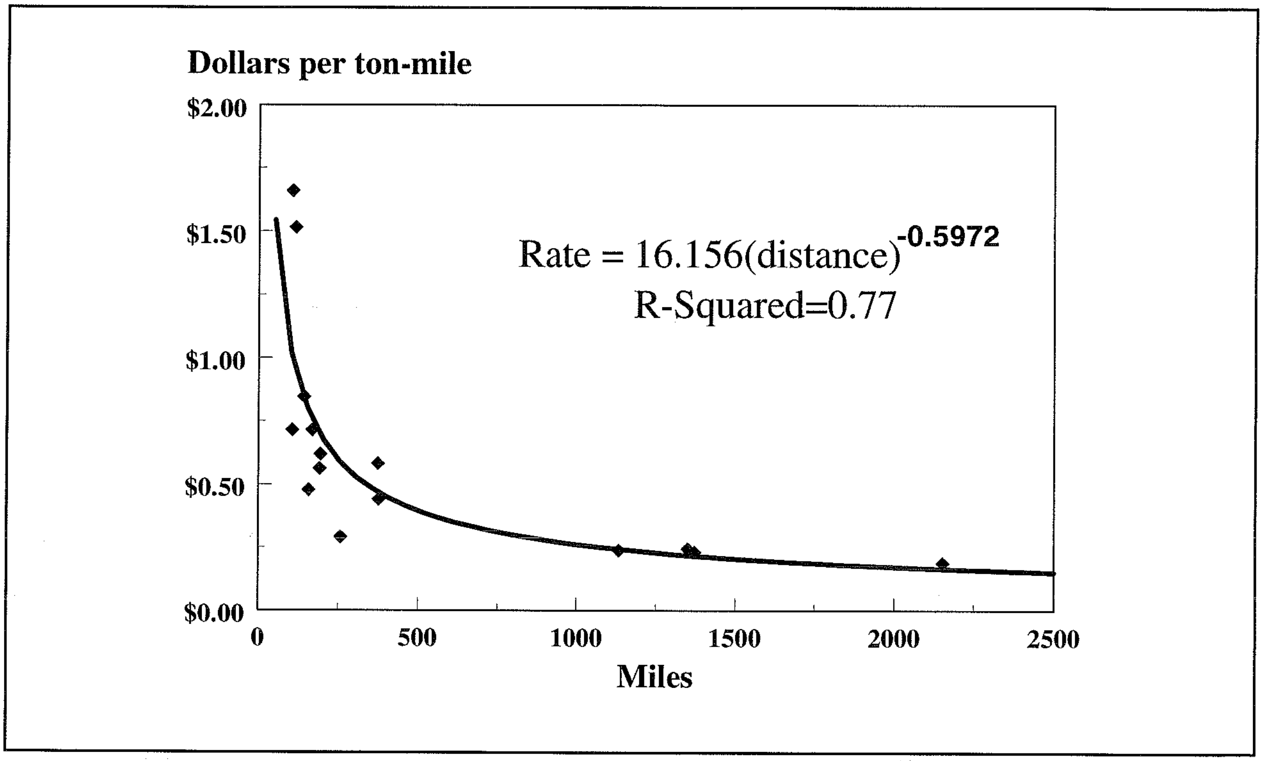

Figure 2-5 Non-linear Model of Rate, in Dollars per Ton-Mile, Versus Distance

Rate Changes

The survey asked how LCV operation had affected the typical rates (compared to non-LCV motor carriers) charged. Fewer than four percent of the respondents to this question said "higher," while 50 percent said "lower," and the remaining 46 percent said "no significant difference." The responses to this question are shown in the bar chart in Figure 2-6. The results drawn from this question provide no direct evidence that LCVs have uniformly reduced costs and hence lowered rates. Presumably some economies were gained by utilizing LCVs, otherwise the carrier would have not used LCVs. However, this finding supports the contention that the benefits (cost savings) resulting from the use of LCVs do not directly result in lower prices. Rather, LCV services may, in many cases, result in greater flexibility in the use and allocation of equipment.

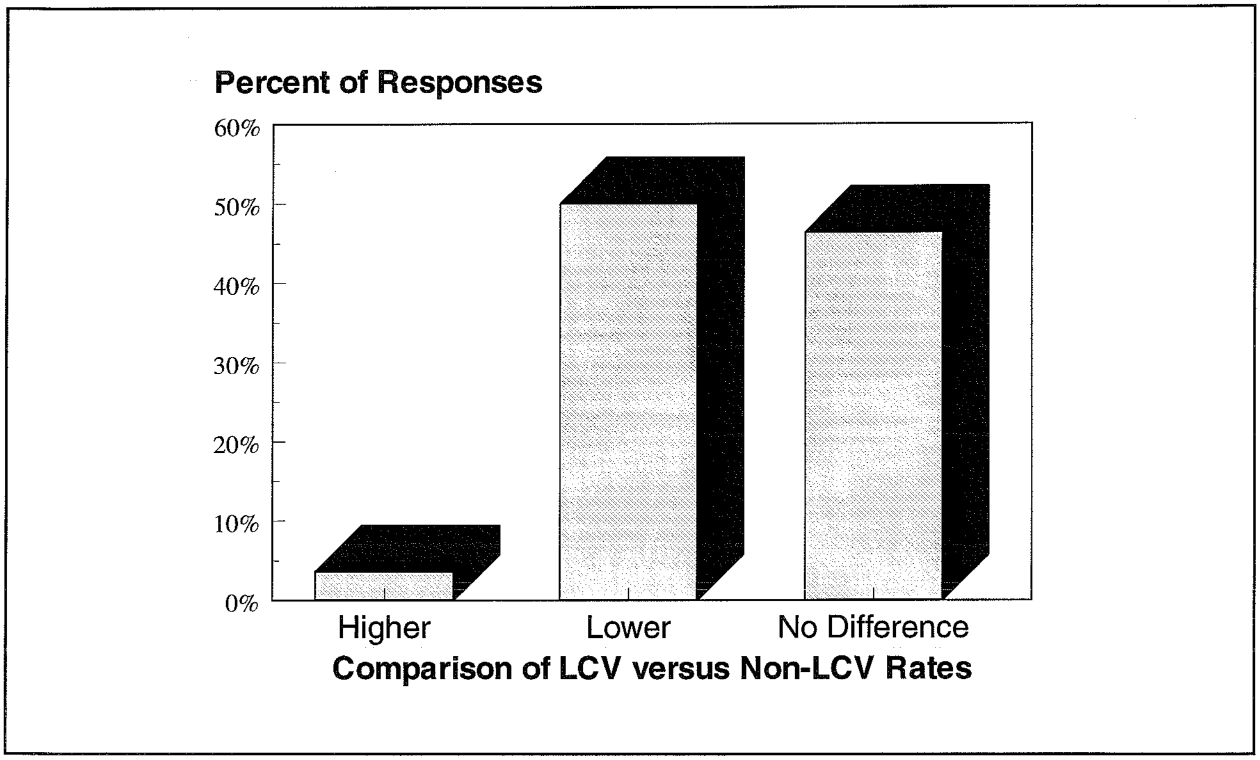

Figure 2-6 Comparison of Rate Levels Between Freight Hauled In LCVs Versus Non-LCVs

Freight Diversion

When asked which mode would probably be selected if the freight described above were not carried on the respondents' LCVs, as reported in Figure 2-7 94 percent said "standard tractor-trailers," and six percent said "railroad." Other modes in the multiple-choice list (air, water, and intermodal) were not selected. The diversion of freight indicated by the respondents in this sample would be mostly between types of trucking equipment, with a small minority of the responses indicating a shift between LCV trucking and railroads. In other words, because of the greater capacity of LCV it is likely there would be more trucks on the road if there were no LCVs.

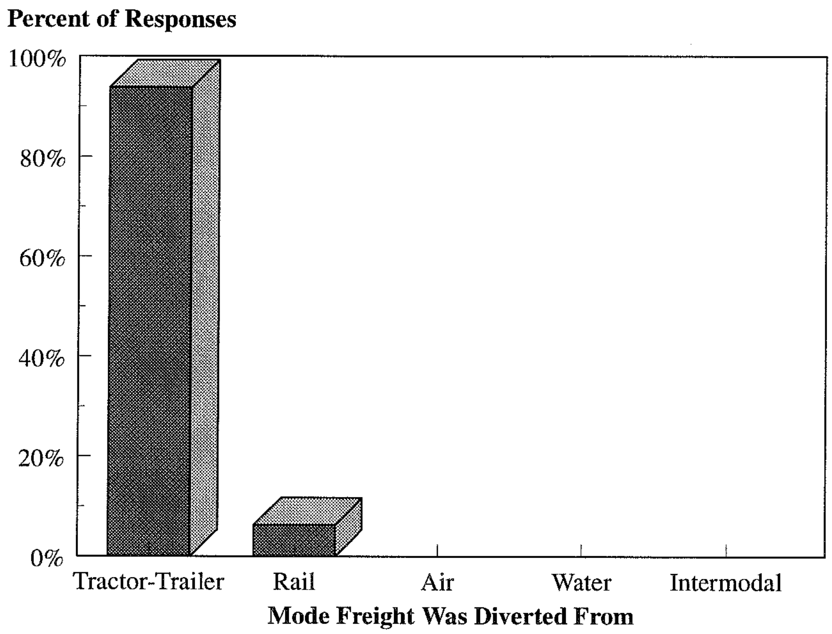

Figure 2-7 Mode If LCVs Were Not Used

Rail carriers are concerned that expanded LCV services would divert a significant volume of currently intermodal traffic to LCVs. Clearly, increasing the productivity of motor carriers through the use of LCVs would result in rate reductions on LCV routes. However, for the LCV carriers surveyed, none believed the traffic they now carry was diverted from intermodal. Further, the rates collected in the survey were compared to current rates for containers over midwestern ramps to the east and west coast. The estimated price for LCV services on a ton-mile basis were several times the rates quoted for similar container movements. Of course, the two costs are not completely comparable since the LCV rate is for door-to-door service or at least terminal-to-terminal service, while the container rates are reported from intermodal ramp to intermodal ramp.

Cost Comparisons

Carriers were asked about their firms' cost experience, comparing LCVs with other vehicles, for labor, fuel, maintenance, insurance and equipment costs. Respondents were asked only if they found LCV costs to be higher, lower, or not significantly different when compared with other vehicles. Results were extremely mixed and provided little for meaningful interpretations. The survey asked, for example are labor costs for LCVs, when compared to non-LCVs, higher, lower, or the same, on a per mile basis. (LCV labor costs on a per vehicle-mile basis are expected to go up, indicating drivers of more complected and larger rigs are paid more for being more highly skilled, or labor costs were the same.) Roughly one-fifth of the respondents indicated the labor costs per mile went down. The preponderance of illogical responses indicates that many of the respondents either did not understand the question or the true impact on labor costs was difficult for the motor carrier to interpret. As an illustration, the responses to the question regarding labor cost per mile are graphed in Figure 2-8. The majority (65 percent) indicated labor costs were higher, but 20

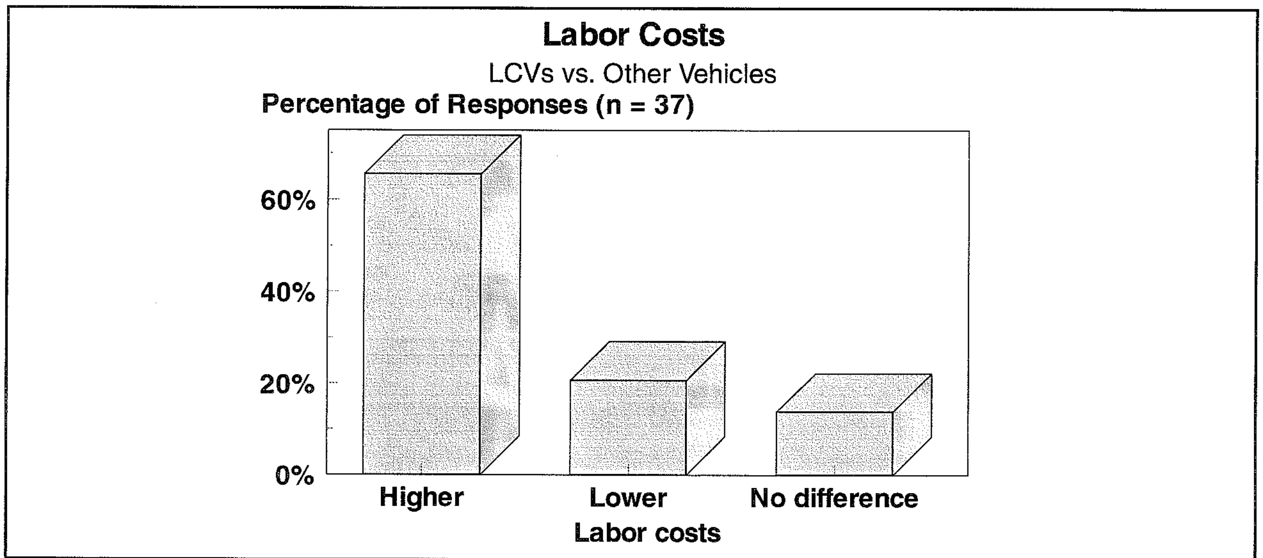

Figure 2-8 Comparison of LCV Labor Costs To Non-LCV Labor Costs per Mile

percent indicated they decreased.

CONCLUSIONS

The evidence collected by this questionnaire supports a contention that the use of LCVs by motor carriers is probably a strategic move to enable these carriers to increase their productivity and better compete with other motor carriers. Much of the rate data collected suggests that rates to shippers are changed little compared to rates using single tractor-trailer rigs. When asked what mode would be used if the freight were not carried on LCVs, respondents almost uniformly said "standard tractor-trailer;" one said rail. There was little evidence found to support a scenario of freight being diverted from rail to LCV. Rather, the use of LCVs is for freight that would most likely be carried on the highways, in one type of equipment or another. The main effect is probably one of increasing productivity to keep rate increases slower than what they would otherwise be without LCVs.

Chapter 3
Commodity Transport and Economic Factors

To identify the traffic that would be potentially shifted to Longer Combination Vehicles, this chapter examines truck and rail commodity flow patterns in Iowa. In this report, the raw data are examine and summarized. In the second phase's report, these data are used to model truck traffic patterns to examine changes in truck traffic as a result of highway network modifications. Whereas the data on rail traffic are rich and available, truck commodity flow data are hard to obtain. In fact, there exists no single database for truck commodity flows in the state or national at a reasonably disaggregate level to conduct within state truck traffic demand analysis. Therefore, truck commodity flow data have to be assembled from different and heterogeneous sources. There are two objectives for this chapter:

1. Identify and analyze major industry segments using employment data from the Census of Manufacturers, Job Services of Iowa records, and county agricultural statistics. Important industry segments are identified based on freight generation and size of employment. In the second phase's report, these data will be used to create a model for truck traffic flows within Iowa and with origins and destinations in other states.

2. Summarize commodity flow data within and through Iowa. Rail commodity flow data are obtained from the 1989 Interstate Commerce Commission (ICC) railroad confidential waybill sample. Iowa truck commodity flows are estimated using the Iowa Department of Transportation truck traffic counts and the truck weight survey of 1989 and 1991. Other data sources used to supplement the truck weight surveys are 1990 Truck Use and Inventory Survey and the 1977 Commodity Transportation Survey.

ECONOMIC BASE DATA

To understand the freight traffic generated and attracted within a region or a state (in this case the State of Iowa) requires knowledge of the types of economic activities conducted. This section is devoted to describing aggregate economic base data. The base data will identify the level of activity of those industries that may potentially transport inputs or outputs using LCVs.

Manufacturing

Employment levels by industry sector and county were obtained from the Rural Data Project, through Iowa State University's Department of Economics. The data were compiled from confidential Iowa Department of Employment Services files for 1989. Major state manufacturing sectors are food and kindred products, machinery, electrical machinery, metal products, and transportation equipment.

The total state employment, for all sectors (including service sectors), is estimated at over 1.1 million employees in 1989. Commodity producing sectors accounted for about 20 percent of that total. Table 3-1 lists these sectors, which are mainly manufacturing sectors, in descending order of number of employees. Each of these industries represents an industry group as indicated by the 2-digit Standard Industry Code (SIC). The percentages in the table are based on the total employment of the listed sectors, and not the total employment in the state.

The largest two sectors in the state, in terms of employment, are food and kindred products and machinery, which together employ about 45,000 employees each (19 percent of total manufacturing employment). Printing and publishing industries ranked third in the number of employees in Iowa, and accounted for about nine percent of the state's manufacturing employment. The fourth industry, in terms of employment, was fabricated metal products, accounting for less than eight percent, followed by electric and electronic equipment which accounted for 6.5 percent, rubber and plastic products at 5.3 percent, instruments at 5.2 percent, and transportation equipment accounted for more than five percent. These industry groups accounted for 77.1 percent of Iowa's employment in non-service sectors. Each of these major industries will be analyzed at the sub-sector level (three-digit SIC codes) to identify their relative employment size and locations by county.

Table 3-1 1989 State Employment by 2-digit Industry Group

SIC	Industry Group	Employees	Percentage	Cumulative Percentage
20	Food and Kindred Products	44,843	19.2	19.2
35	Machinery and Computer Equipment	44,798	19.2	38.4
27	Printing, Publishing	20,793	8.9	47.3
34	Fabricated Metal Products	17,949	7.7	55.0
36	Electronics, except computer equipment	15,056	6.5	61.5
30	Rubber and plastic products	12,434	5.3	66.8
38	Instruments	12,070	5.2	72.0
37	Transportation equipment	11,906	5.1	77.1
33	Primary Metal industries	7,406	3.2	80.2
24	Lumber and wood products, except furniture	6,519	2.8	83.0
25	Furniture and fixtures	6,025	2.6	85.6
32	Stone, clay, glass, and concrete products	5,595	2.4	88.0
28	Chemicals and allied products	5,438	2.3	90.3
23	Apparel	5,120	2.2	92.5
39	Misc Manufactured products	5,082	2.2	94.7
26	Paper and allied products	4,754	2.0	96.8
1	Ag production- crops	2,017	0.9	97.6
2	Ag production- livestock and animal specialties	1,915	0.8	98.4
14	Mining	1,840	0.8	99.2
31	Leather and leather products	908	0.4	99.6
22	Textile mill products	608	0.3	99.9
29	Petroleum refining and related industries	180	0.1	100.0
12	Coal mining	100	0.0	100.0
	Total	233,356		

Food and kindred products industries (SIC 20) have a wide array of products, which include: meat; dairy products; canned and preserved fruits, vegetables, and sea foods; grain mill products (flour, cereal, corn starch, etc.); bakery products; and others. Meat products has the largest employment level among food industries in Iowa, and accounts for about 53 percent of the sector's employment, employing 23,640 people. The second largest food industry in Iowa is grain mill products, which employs 9,488 workers, or 21 percent of the food industry employment in the state. Dairy and bakery products accounted for 6.9 percent and 5.7 percent, respectively. The percentage of total food and kindred product industries employment in Iowa in each category is listed in Table 3-2.

To describe the spatial distribution of employment and location of industries, employment is aggregated by county. Figure 3-1 contains a map of Iowa and Iowa counties to provide a point of reference for county level employment quantities.

Table 3-2 Iowa Employment in Food and Kindred Products Industries

SIC	Food Industry	Employees	Percentage	CumulativePercentage
201	Meat Products	23,640	52.7	52.7
204	Grain Mill Products	9,488	21.2	73.9
202	Dairy Products	3,093	6.9	80.8
205	Bakery Products	2,554	5.7	86.5
203	Preserved Fruits and	2,108	4.7	91.2
207	Fats and Oils	1,448	3.2	94.4
208	Beverages	1,406	3.1	97.5
209	Misc.	775	1.7	99.3
206	Sugar, Confectionery	331	0.7	100.0
	Total	44,843		

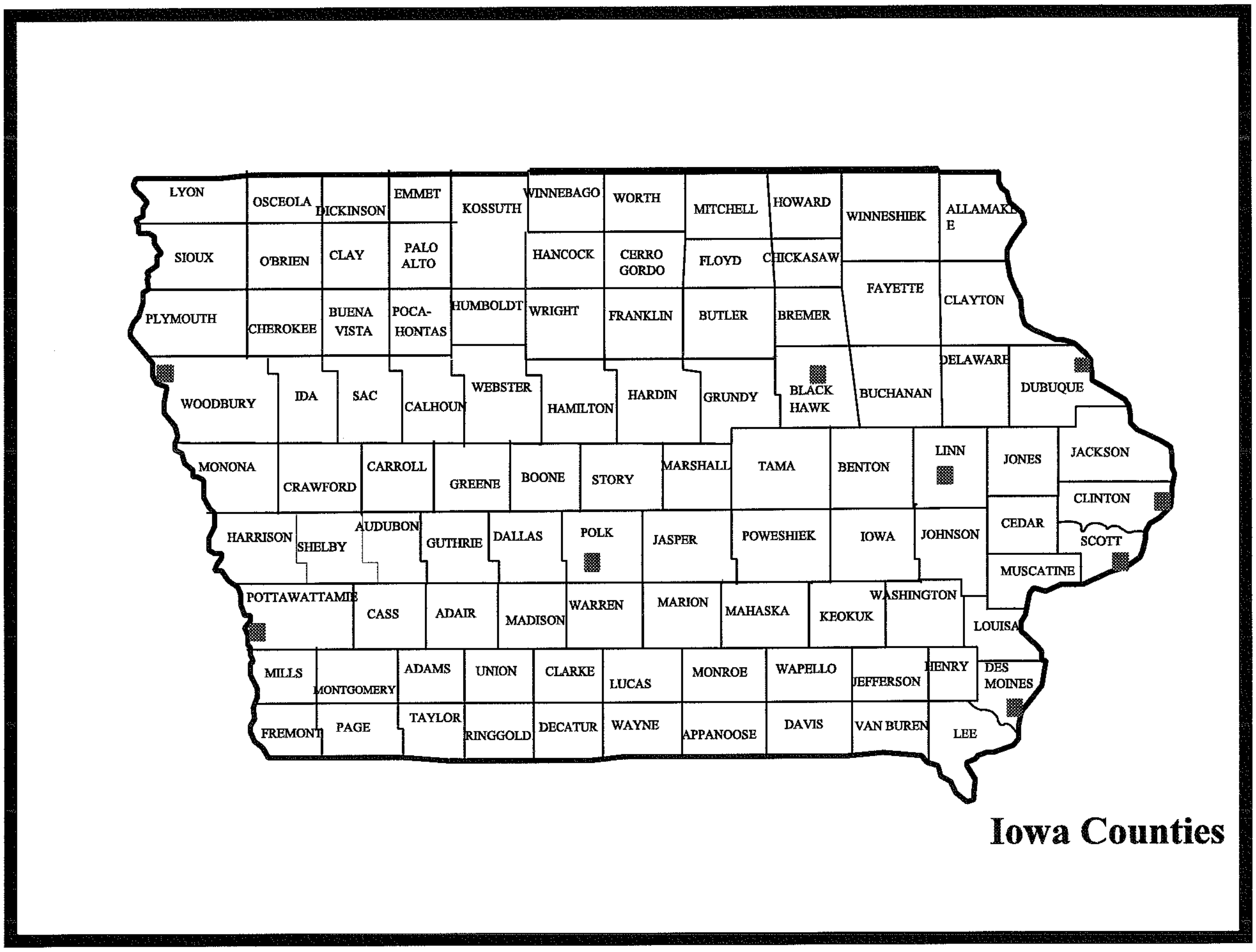

Figure 3-1 Map of Iowa and Iowa Counties

Geographically, food industries are located in a large number of counties. After analyzing the county level employment of meat packing industries (SIC 201) in Iowa, it is concluded that no major concentration of employment can be identified. Counties with the largest employment concentration in this sector include Woodbury, Dubuque, Buena Vista, Linn, Polk, Crawford, Scott, Louisa, Muscatine, and Marshall accounting for a total of 64.7 percent of this sector's employment.

County employment patterns of grain mill products shows some concentration in a few counties. Linn county, with a center of activity in the City of Cedar Rapids, is a major hub for the food processing industries, and contains about 32 percent of state employment in grain mill products. Muscatine county has the second highest concentration of grain mill industries employees, accounting for 11.6 percent, followed by Clinton county with 8.7 percent, Lee county with 6.5 percent, Scott county with 6.4 percent, Webster county with 5.1 percent, and Polk county with 5.1 percent of the state employment in that industry.

Machinery production sector (SIC 35) has the second largest Iowa employment concentration and includes the following subsectors (listed in order of employment): farm and garden machinery (36.6 percent of the total machinery production employment), construction related machinery (23.6 percent), miscellaneous machinery (11.4 percent), refrigeration and service machinery (6.5 percent), and special industry machinery (6.5 percent). Table 3-3 lists the number of employees by subsector of Iowa's machinery sector. About half of the farm and garden machinery employees are located in Black Hawk county. Polk county had almost 2,000 employees, or 12 percent of this sector's employment, while Wappello county accounted for 7.7 percent.

Table 3-3 Iowa Employment in Machinery Industries

SIC	Machinery Industry	Employees	Percentage	CumulativePercentage
352	Farm and Garden Machinery	16,390	36.6	36.6
353	Construction related	10,561	23.6	60.2
359	Misc. except electric	5,108	11.4	71.6
358	Refrigeration and service	2,934	6.5	78.1
355	Special Industry	2,919	6.5	84.6
354	Metalworking	2,779	6.2	90.8
356	General Industrial	2,376	5.3	96.1
357	Office and Computing	1,461	3.3	99.4
351	Engines and Turbines	270	0.6	100.0
	Total	44,798		

The third largest industrial sector in Iowa in terms of 1989 employment is printing and publishing (SIC 27). The three subsectors dominating this industry are: commercial printing (33.8 percent of printing and publishing state employment), newspapers (31.8 percent), and periodicals (14.8 percent). These three industries combined accounted for more than 80 percent of the number of employees in printing and publishing in Iowa, as identified in Table 3-4. Polk county, with the Des Moines metropolitan area has the highest employment of commercial printing (35 percent of state's total). Other significant employment concentrations are also in counties which contain metropolitan areas such as Scott, Linn, and Dubuque counties (they contain the Cities of Davenport, Cedar Rapids, and Dubuque, respectively). Newspapers employment is sparsely distributed among Iowa counties, while periodicals production employment is dominantly located in Polk county (about 70 percent).

Table 3-4 Iowa Employment in Printing Industries

SIC	Printing Industry	Employees	Percentage	Cumulative Percentage
275	Commercial Printing	7,036	33.8	33.8
271	Newspapers	6,603	31.8	65.6
272	Periodicals	3,081	14.8	80.4
276	Manifold Business Forms	1,320	6.3	86.8
273	Books	878	4.2	91.0
274	Misc. Publishing	781	3.8	94.7
279	Printing trade services	591	2.8	97.6
278	Blankbooks and book binding	503	2.4	100.0
	Total	20,793		

Fabricated metal products (SIC 34) employed about 18,000 workers in Iowa in 1989, about 7.7 percent of the state total manufacturing employment. More than 80 percent of the employment in this sector is in the following subsectors: miscellaneous fabricated metal (29.6 percent of the total fabricated metals product employment), fabricated structural metal (22.5 percent), metal forging and stamping (17.7 percent), and ordnance and accessories (10.6 percent). Table 3-5 shows a listing of employment levels for these industries. The majority of the miscellaneous metal industries employment is located in Marshall county which includes about 43 percent of the state employment in the sector. Employment for fabricated structural metal is distributed among more counties in Iowa. Ordnance and accessories employment is located in two counties: Des Moines (69.5 percent of the total ordnance and accessories employment) and Black Hawk (30.4 percent).

Table 3-5 Iowa Employment in the Fabricated Metal Industries

SIC	Fabricated Metal Industry	Employees	Percentage	CumulativePercentage
349	Misc. fabricated metal	5,319	29.6	29.6
344	Fabricated structural metal	4,041	22.5	52.1
346	Metal forging and stamping	3,178	17.7	69.9
348	Ordnance and accessories	1,904	10.6	80.5
342	Cutler and handtools	1,476	8.2	88.7
345	Screw machine products	1,006	5.6	94.3
343	Plumbing and heating	498	2.8	97.1
347	Metal services	274	1.5	98.6
341	Metal cans	253	1.4	100.0
	Total	17,949		

Electric and electronic equipment (SIC 36) industries employed 15,056 employees in Iowa in 1989, mainly concentrated in the following subsectors: household appliances (SIC 363) with 39.6 percent of the total electronic equipment employment, electronic components and accessories (SIC 367) with 15.6 percent, miscellaneous electrical equipment (SIC 369) with 12.8 percent, electrical industrial apparatus (SIC 362) with 10.6 percent, and electrical distribution equipment (SIC 361) with 9.2 percent. Table 3-6 provides a listing of employment totals of sub-industries of the electrical equipment industry. The majority of household appliances employment is located in two counties about 55 percent is in Jasper county and 42 percent is in Iowa county. More than 85 percent of the employment in electronic equipment and accessories is located in Marion, Des Moines, Clayton, Story, Johnson, and Sioux counties. Major miscellaneous electrical equipment employment are located in Des Moines (39.4 percent), Delaware (17.7 percent), Cerro Gordo (12 percent), and Apanoose counties (10.1 percent).

Table 3-6 Iowa Employment for Electronic Industries (Excluding Computer Equipment)

SIC	Electronic Industry	Employees	Percentage	CumulativePercentage
363	Household appliances	5,969	39.6	39.6
367	Electronic components, access.	2,350	15.6	55.3
369	Misc. electrical equipment	1,932	12.8	68.1
362	Electric industrial apparatus	1,595	10.6	78.7
361	Electric distributing equipment	1,383	9.2	87.9
366	Communication equipment	1,103	7.3	95.2
364	Electric lighting, wiring equipment	519	3.4	98.6
365	Radio, TV receiving equipment	205	1.4	100.0
	Total	15,056		

The rubber and plastic industries (SIC 30) employees 12,434 Iowans, or 5.3 percent of the state total non-service sectors employment. There are three main rubber and plastic industries that accounted for 97.3 percent of the employment in this sector: miscellaneous plastic products (SIC 308) accounted for 63.8 percent, tires and inner tubes (SIC 301) accounted for 29.3 percent, and hoses and gaskets (SIC 305) accounted 4.1 percent, as shown in Table 3-7. Miscellaneous plastic production employment trends were examined, but no evident concentration in a geographical area could be identified. Counties containing larger metropolitan areas have more employees per county than rural areas. Tire productions was concentrated in two counties, Polk County contained 80.9 percent of the state's tire production employees and Muscatine county contained 19.1 percent.

Table 3-7 Iowa Employment in Rubber and Plastic Industries

SIC	Rubber Industry and Plastics Industries	Employees	Percentage	Cumulative Percentage
308	Misc. plastic products	7,938	63.8	63.8
301	Tires and inner tubes	3,646	29.3	93.2
305	Hose and belting, gaskets and packing	509	4.1	97.3
306	Fabricated rubber	341	2.7	100.0
	Total	12,434		

The instruments industries (SIC 38) employed 12,070 Iowans in 1989 in the following sectors: engineering and scientific instruments (SIC 381) accounted for 81.8 percent of the total instrument industries employment, measuring and controlling devices (SIC 382) accounted for 10.8 percent, and medical instruments, watches and clocks (SIC codes 384 and 387) accounted for 5.1 percent. Table 3-8 lists the total employment numbers for these subsectors. The largest concentration of employment in engineering and scientific instrument production is in Linn County containing about 84.5 percent of the state's employment in that sector. About 83.5 percent of the measuring and controlling devices employment is located in five counties: Webster County with 26.2 percent of the measuring and controlling devices employment, Dubuque County with 21.7 percent, Story County with 18.3 percent, Linn County with 9.9 percent, and Polk County with 7.4 percent.

Table 3-8 Iowa Employment in Instruments Industries

SIC	Instrument Industry	Employee	Percentage	Cumulative Percentage
381	Engineering, Scientific instruments	9,878	81.8	81.8
382	Measuring, controlling devices	1,306	10.8	92.7
384	Medical instruments	355	2.9	95.6
387	Watches and clocks	269	2.2	97.8
385	Ophthalmic goods	136	1.1	99.0
386	Photographic equipment	126	1.0	100.0
	Total	12,070		

Finally, transportation equipment industries (SIC 37) employed 11,906 Iowans in 1989, and accounted for 5.1 percent of the state's non-service sectors employment. The majority of employment in this industry is in motor vehicles and equipment (SIC 371) 83.5 percent, aircraft and parts (SIC 372) accounted for 7.2 percent of the employment, and miscellaneous transportation equipment (SIC 379) accounted for 7.2 percent, as shown in Table 3-9. More than one fourth of Iowa's employment in motor vehicles and equipment manufacturing is located in Winnebago County. Other significant employment locations were at Wright, Fremont, Story, and Woodbury Counties. Aircraft and parts employment was located in two counties: Polk County contained 49.9 percent of the employment and Scott County contained 49.4 percent.

Table 3-9 Iowa Employment in Transportation Equipment Industries

SIC	Transportation Equipment Industries	Employees	Percentage	Cumulative Percentage
371	Motor vehicles and equipment	9,942	83.5	83.5
372	Aircraft and parts	855	7.2	90.7
379	Misc. transportation equipment	853	7.2	97.8
374	Railroad equipment	193	1.6	99.5
373	Ship, boat building	57	0.5	99.9
375	Motorcycles, bicycles	6	0.1	100.0
	Total	11,906		

Agriculture

Field Crops. The department of agriculture publishes reports on crops and livestock productions by county. The 1989 Iowa Crop County Estimates, prepared by Iowa Agricultural Statistics in Des Moines, Iowa, provides information on the area of farms by crop type, the yield per acre, and the total county production in bushels or tons for each of the 99 counties in the state. The 1989 Iowa Livestock County Estimates similarly provides information on inventory and marketings of hogs, cattle (beef and milk), and sheep in the state by county.

County farm acreage is used to identify major crops producing areas and production rates in tons or bushels per acre. The estimates provide information on the amount of farm acreage by crop for each county in Iowa. For these crops, an estimate of production per acre is computed based on an average of historical yield and area of farm land. Crops included in the report are corn, corn silage, soybeans, oats, wheat, alfalfa, and hay.

Table 3-10 lists the area of farm land for each crop and state productions in tons or bushels. Corn is the number one crop in Iowa in terms of farm land area and the amount of yield. In 1989, there were about 12.25 million acres of corn planted in Iowa, which yielded more than 1.4 billion bushels of corn. Corn farming occupied 57.4 percent of Iowa's farm land area, and accounted for 79.2 percent of its total crop yield. Soybeans is the second major crop in Iowa, with an area of 8.28 million acres, and about 322,920 bushels. The area of farm land planted with soybeans occupied 38.8 percent of the state's farming area, and produced about 17.7 percent of Iowa's total yield. Oats and wheat production amounted to very small amounts, compared to the high yield of corn and soybeans. Corn and soybeans farm acreage was concentrated in the northern two thirds of the state.

Table 3-10 Iowa Farm Land Acreage by Crop

Crop	Acres	Yield (000 Bu)	Percentage	Cumulative Percentage
Corn	12,250,000	1,445,500	79.2	79.2
Soybeans	8,280,000	322,920	17.7	96.9
Oats	750,000	54,000	3.0	99.8
Wheat	70,000	3,290	0.2	100.0
Total	21,350,000	1,825,710		
All Hay	2,400,000	6,650,000 Tons		
Alfalfa	1,900,000	5,700,000 Tons		
Corn Silage	340,000	4,590,000 Tons		

Livestock. The three main livestock in the state are cattle, hogs, and sheep. The beef industry in Iowa is very important to the state economy. There were more than 1.2 million beef cows and 308,000 milk cows in Iowa in 1989 (Iowa Livestock County Estimates). These livestock were mainly located in the northwestern, west central, and the east central parts of the state. There were over 22.5 million hogs in Iowa in 1989. Sheep marketings in the state amounted to 317,000 in 1989. Livestock is moved to processing plants or slaughter plants across the state.

Economic Base Data Summary

The economic base data identified a very few industries dominate Iowa's economy. The predominate manufacturing sectors are only seven manufacturing sectors account for over 75 percent of the non-agricultural commodity producing sectors. With the exception of meat products, the employment in these sectors is concentrated in few locations throughout the state. In addition, agricultural production is concentrated within a few commodities but is spread widely across the state. The concentration of non-agricultural employment within a few commodity producing sectors and within a few locations means the majority of non-agricultural freight traffic patterns can be characterized fairly easily by examining only these few important sectors. Depending on the coverage and access to a Iowa LCV network, the implication on these sectors can be hypothesized. For example, if Iowa were to widely allow the use of intermediate doubles throughout the state, allow access to agricultural areas of the state, the change in traffic patterns would be dramatic. Intermediate doubles are well suited for the hauling of bulk commodities. More truck movements of grain are likely to occur directly from local storage(on and off farms) to processing facilities and river ports, thus reducing the volume of grain moving interstate by rail and increasing amount of truck traffic on the rural secondary and primary roads. On the other hand, if LCV were restricted to the interstate and facilities designed to interstate standards, the impact of a LCV network is likely to be negligible.

In the next section, commodity flow patterns carried by rail are examined, followed by an examination of truck commodity flow patterns.

FREIGHT TRAFFIC PATTERNS

The following sections review freight traffic patterns based on origin and destination samples of rail and truck shipments. The rail data are readily available but truck data are relatively sparse. In the report on the second phase of this project, these data will be used to identify commodity and origin/destination relationships to permit the modeling to truck traffic flows in and through Iowa. The following sections first deal describe the rail traffic data available and relevant trends, followed by a similar section for trucking.

Rail Traffic Trends

Data on rail shipment movements were obtained from the 1989 railroad waybill sample prepared by the Interstate Commerce Commission.[1] A confidential version that covers all rail movements, including intermodal traffic, originating in, terminating in, or crossing the State of Iowa was requested by the Iowa Department of Transportation. The confidential waybill files include shipment weight, commodity shipped, state and county of origin, state and county of

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1 This was the most recent data that were available when the project was initiated. All other data reported were also collected in 1989.

destination, the railroads involved in the shipment, and whether the shipment is intermodal (TOFC or COFC). In summarizing rail commodity flows, frequency analysis of commodities shipped were cross tabulated by origin and destination using SAS (Statistical Analysis System). Commodities were ranked in order of tonnage shipped for railcar traffic or the number of trailers and containers for intermodal shipments, and are tabulated in that order. Each of the summaries consists of a breakdown of the major commodities shipped, the tonnage shipped, and the percentage commodity tonnage to the total tonnage.

Intermodal Traffic: Originating Traffic. A total of 25,100 trailers and containers originated in Iowa in 1989. Major commodities shipped from the state were miscellaneous and mixed shipments, electrical machinery, transportation equipment, food and kindred products, empty containers, and contract traffic. These major commodities together accounted for more than 90 percent of the total number of trailers and containers shipped. As shown in Table 3-11, Miscellaneous mixed shipments accounted for the largest loadings from Iowa, about 41 percent of the number of trailers and containers. Electrical machinery and transportation equipment accounted for 20.4 and nine percent, respectively. Shipments of food and kindred products and empty containers amounted to about 5.5 percent each. In 1989, the bulk of Iowa's traffic (64 percent) terminated in three states: California 30.3 percent, Illinois 21.7 percent, and Missouri 12.2 percent. Table 3-12 shows the number of trailers and containers shipped from Iowa to the most common destinations.

The predominate commodity from Iowa in containers is miscellaneous and mixed shipments and it is most commonly destine to Kansas City, Missouri, Los Angles, California, Chicago, Illinois, Denver, Colorado, and Houston, Texas. The most frequent origins were Linn, Polk, Scott, Black Hawk, and Lee Counties. The most frequent origins and destinations are illustrated in Figure 3-2.

Table 3-11 1989 Intermodal Traffic Originating in Iowa by Commodity

STCC	Commodity	Number of Trailers and Containers	Percentage	Cumulative Percentage
46	Misc. mixed shipments	10,284	41.0	41.0
36	Electrical machinery	5,120	20.4	61.4
37	Transportation equipment	2,340	9.3	70.7
20	Food and kindred products	2,240	8.9	79.6
42	Empty containers	1,436	5.7	85.3
43	Contract traffic	1,400	5.6	90.9
35	Machinery, except electric	760	3.0	93.9
25	Furniture	740	2.9	96.9
30	Pulp, paper and allied products	280	1.1	98.0
45	Shipper association traffic	240	1.0	99.0
Sum (listed)		24,840		
Total		25,100		

Table 3-12 1989 Intermodal Traffic Originating in Iowa by Destination

Destination	Number of Trailers and Containers	Percent	Cumulative Percent
California	7,616	30.3	30.3
Illinois	5,452	21.7	52.0
Missouri	3,072	12.2	64.2
Texas	1,720	6.9	71.1
Colorado	1,320	5.3	76.4
Virginia	1,080	4.3	80.7
Florida	1,000	4.0	84.7
Tennessee	720	2.9	87.6
Washington	640	2.5	90.1
Oregon	520	2.1	92.2
Total (listed)		23,140	
Total (All Destinations)		25,100	

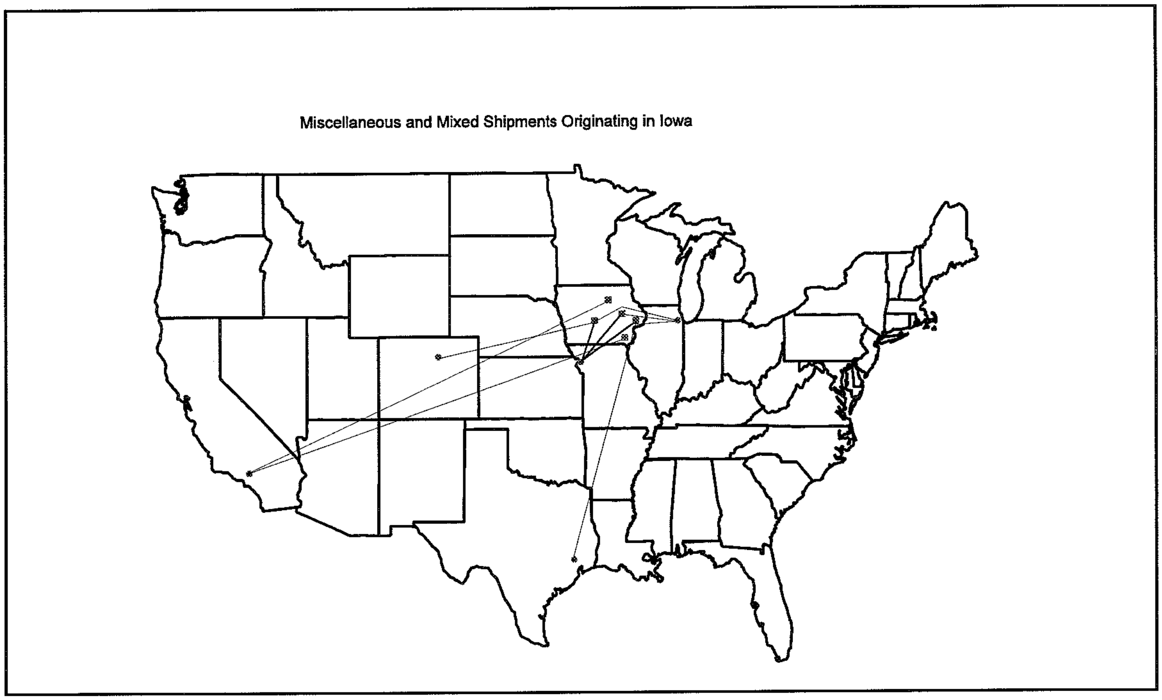

Figure 3-2 Intermodal Traffic Originating in Iowa: Miscellaneous and Mixed shipments

Intermodal Traffic: Terminating Traffic. Intermodal traffic terminating in Iowa has changed dramatically by nearly doubling in magnitude between 1987 and 1989.(1) As shown in Table 3-13, a total of 16,720 trailers and containers terminated in Iowa in 1989. Miscellaneous mixed shipments accounted for the largest portion of the total number of trailers and containers terminating in Iowa, about 64 percent. However, Transportation Equipment shipments to Iowa grew from a negligible amount in 1987, to 21 percent of total terminating traffic in 1989. Chemicals and Food products were some of the commodities with modest number of trailers and containers terminating in Iowa in 1989. More than 84 percent of traffic terminating in Iowa originated in three states, California, Illinois, and Missouri. Table 3-14 identifies the number of trailers and containers terminating in Iowa from major originating states.

Table 3-13 1989 Intermodal Traffic Terminating in Iowa by Commodity

STCC	Commodity	Number of trailers and Containers	Percent	Cumulative Percent
46	Misc. mixed shipments	10,680	63.9	63.9
37	Transportation equipment	3,488	20.9	84.8
28	Chemicals and allied products	740	4.4	89.2
42	Empty containers	680	4.1	93.3
20	Food and kindred products	612	3.7	97.0
43	Contract traffic	200	1.2	98.2
26	Pulp, paper, and allied products	80	0.5	98.7
24	Lumber and wood products	80	0.5	99.2
29	Petroleum or coal products	40	0.2	99.4
14	Nonmetallic minerals	40	0.2	99.6
45	Shipper associations traffic	40	0.2	99.8
25	Furniture and fixtures	40	0.2	100.0
	Total	16,720		

Table 3-14 1989 Intermodal Traffic Terminating in Iowa by Origin

Origin State	Number of Trailers and Container	Percentage	Cumulative Percentage
California	7,412	44.3	44.3
Illinois	5,468	32.7	77.0
Missouri	1,220	7.3	84.3
Texas	560	3.3	87.7
Washington	500	3.0	90.7
Kansas	320	1.9	92.6
Georgia	200	1.2	93.8
Iowa	180	1.1	94.9
Virginia	160	1.0	95.8
Colorado	160	1.0	96.8
Minnesota	140	0.8	97.6
Nebraska	120	0.7	98.3
Louisiana	80	0.5	98.8
North Carolina	40	0.2	99.0
Pennsylvania	40	0.2	99.3
Oregon	40	0.2	99.5
New Mexico	40	0.2	99.8
Alabama	40	0.2	100.0
Total	16,720		

Intermodal Traffic: Bridge Traffic. Iowa is a major conduit for intermodal shipments between the West Coast and Midwest and East Coast destinations. Intermodal traffic originating or terminating in Iowa is negligible compared to the number of trailers and containers moving through Iowa. In 1989, there was a total of about 1.4 million trailers and containers crossed Iowa representing a 25 percent increase in the bridge traffic across Iowa in only two years(2). The majority of Iowa's bridge traffic is miscellaneous and mixed shipments, totalling more than 940,000 trailers and containers or 67 percent, as summarized in Table 3-15. Shipper associations traffic accounted for 5.6 percent of the total, while food and kindred products accounted for 3.8 percent of the total, empty containers 3.6 percent, field products 3.5 percent, and transportation equipment, accounting for 3.4 percent.

More than 36 percent of Iowa's bridge traffic involved an international movement. Of the 36 percent of total bridge movements were 13.9 percent imported commodities, 13.6 percent exported commodities, and 9.2 percent imported and exported commodities (land bridge traffic). Bridge intermodal traffic that did not involve an international movement amounted to 21.6 percent of the total, while 41.8 percent of the total was of unknown type. Import and export shipments commonly move by dedicated double stack trains, and have little potential for being shifted to another mode due to efficiency of double stack trains, the long distance of the trip, and high volume origins and designations.

The major movement on this corridor is between Illinois and California, accounting for 45.4 percent (in both directions) of all intermodal traffic through Iowa, as shown in Table 3-16. Other significant origin and destination pairs include Washington and Illinois, 10.7 percent; Illinois and Oregon, 4.4 percent; Illinois and Nebraska, 5.1 percent; and Illinois and Texas, 4.6 percent of the total bridge traffic across Iowa.

The California - Illinois corridor is almost balanced in terms of shipments of containers and trailers in both directions. Intermodal shipments from and to California were concentrated in three areas, the Los Angles and Long Beach region, the San Francisco Bay region, and the Fresno area, whereas shipments to and from Illinois are concentrated in Chicago and its vicinity. Table 3-17 lists the number of trailers and containers shipped from each region of California to Illinois and Figure 3-3 illustrates the flow. Table 3-18 lists the number of trailers and containers shipped from Illinois to each region of California and Figure 3-4 illustrates the flow. Table 3-19 list the number of trailers and containers shipped across Iowa from other major origins and designations than California and Figure 3-5 illustrates the flow.

Table 3-15 1989 Intermodal Bridge Traffic Through Iowa By Commodity

STCC	Commodity	Number of Trailers and containers	Percentage	Cumulative Percent
46	Misc. mixed shipments	940,377	67.3	67.3
45	Shippers associations traffic	78,436	5.6	73.0
20	Food and kindred products	53,169	3.8	76.8
42	Empty containers	50,240	3.6	80.4
1	Field products	49,004	3.5	83.9
37	Transportation equipment	47,118	3.4	87.2
43	Contract traffic	34,820	2.5	89.7
28	Chemicals and allied products	24,656	1.8	91.5
24	Lumber and wood products	20,060	1.4	92.9
44	Freight forwarder traffic	17,720	1.3	94.2
36	Electrical machinery	14,960	1.1	95.3
33	Primary metal products	11,240	0.8	96.1
26	Pulp, paper and allied products	8,920	0.6	96.7
35	Machinery, except electrical	6,868	0.5	97.2
	Total (listed commodities)	1,357,588		
	Total (all commodities)	1,396,572		

Table 3-16 Intermodal Bridge Traffic Through Iowa by Origin-Destination

Origin State	Destination	Number of Trailers and Containers	Percentage	Cumulative Percent
Illinois	California	327,976	22.8	22.8
California	Illinois	324,770	22.6	45.4
Washington	Illinois	85,597	6.0	51.4
Illinois	Washington	67,700	4.7	56.1
Illinois	Oregon	54,520	3.8	59.9
Illinois	Nebraska	48,740	3.4	63.3
Illinois	Texas	38,260	2.7	66.0
Texas	Illinois	27,023	1.9	67.9
Illinois	Kansas	24,352	1.7	69.6
Nebraska	Illinois	24,184	1.7	71.3
Kansas	Illinois	24,088	1.7	73.0
Illinois	Colorado	23,516	1.6	74.6
California	New Jersey	22,880	1.6	76.2
Illinois	Utah	18,420	1.3	77.5
New Jersey	California	16,120	1.1	78.6
Colorado	Illinois	12,116	0.8	79.4
Tennessee	Washington	11,520	0.8	80.2
Illinois	Arizona	11,504	0.8	81.0
Pennsylvania	California	9,280	0.6	81.6
Missouri	Colorado	8,600	0.6	82.2
Utah	Illinois	8,360	0.6	82.8
Oregon	Illinois	8,269	0.6	83.4
Illinois	Oklahoma	7,791	0.5	83.9
Indiana	California	7,616	0.5	84.4
California	Indiana	7,412	0.5	84.9
Montana	Washington	7,320	0.5	85.4
Washington	Tennessee	6,960	0.5	85.9
California	Massachusetts	6,920	0.5	86.4
Total (listed states) 1,241,814				
Total (all O-D pairs) 1,438,814				

Table 3-17 Intermodal Bridge Traffic: California to Illinois

Origin\Destination	Chicago Area	Other Illinois	Sum	Percent †
Los Angles Area	212,687	3,024	215,711	15.4
San Francisco Area	70,695	460	71,155	5.1
Fresno	25,552		25,552	1.8
Other California	7,768		7,768	0.6
Sum	316,702	3,484	320,186	22.9
Percent †	22.7	0.2	22.9	

† Percent of total intermodal bridge traffic

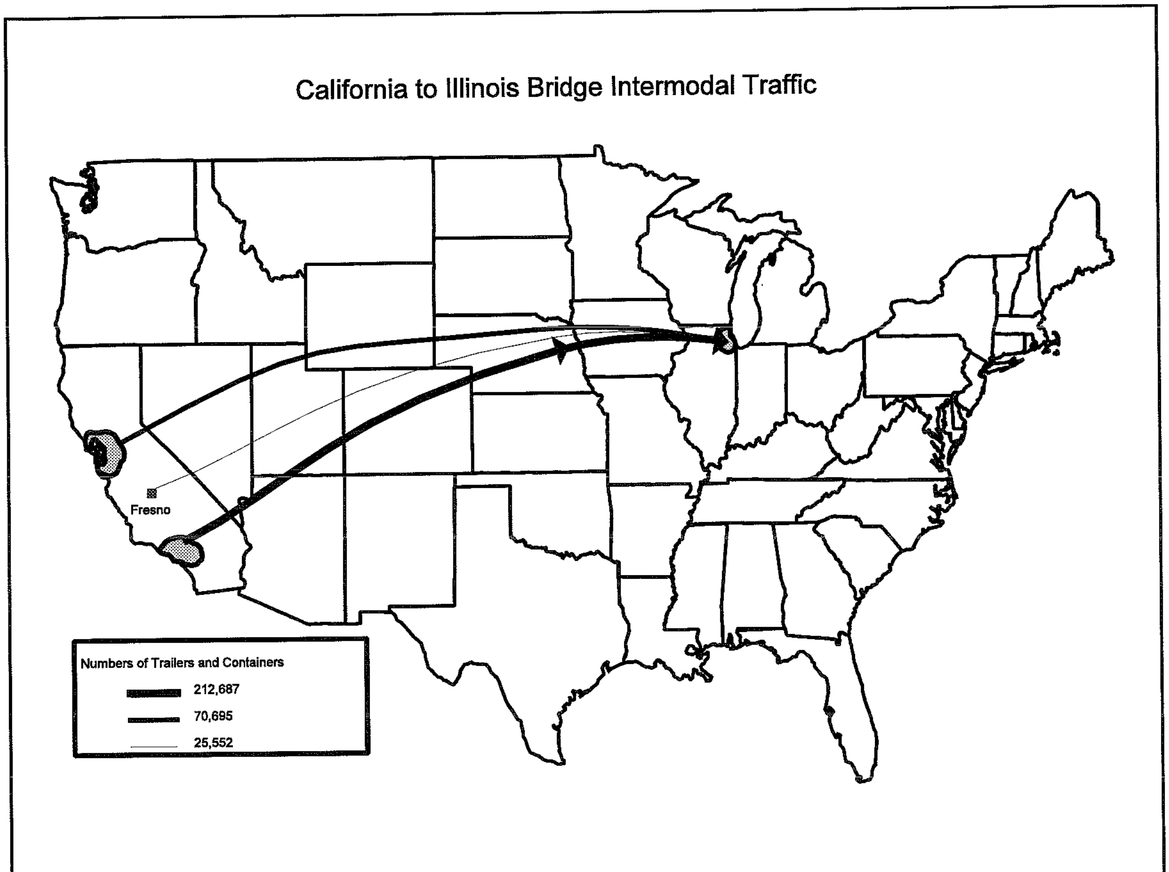

Figure 3-3 Intermodal Bridge Traffic Movements from California to Illinois

Table 3-18 Intermodal Bridge Traffic: Illinois to California

Origin\Destination	Los Angles Area	San Francisco Area	Fresno	Other California	Sum	Percent†
Chicago	184,505[4]	123,900	4,941	1,640	314,986	22.6
Other Illinois	2,160	2,800	40	200	5,200	0.4
Sum	186,665	126,700	4,981	1,840	320,186	22.9
Percent†	13.4	9.1	0.4	0.1	22.9	

† Percent of total intermodal bridge traffic

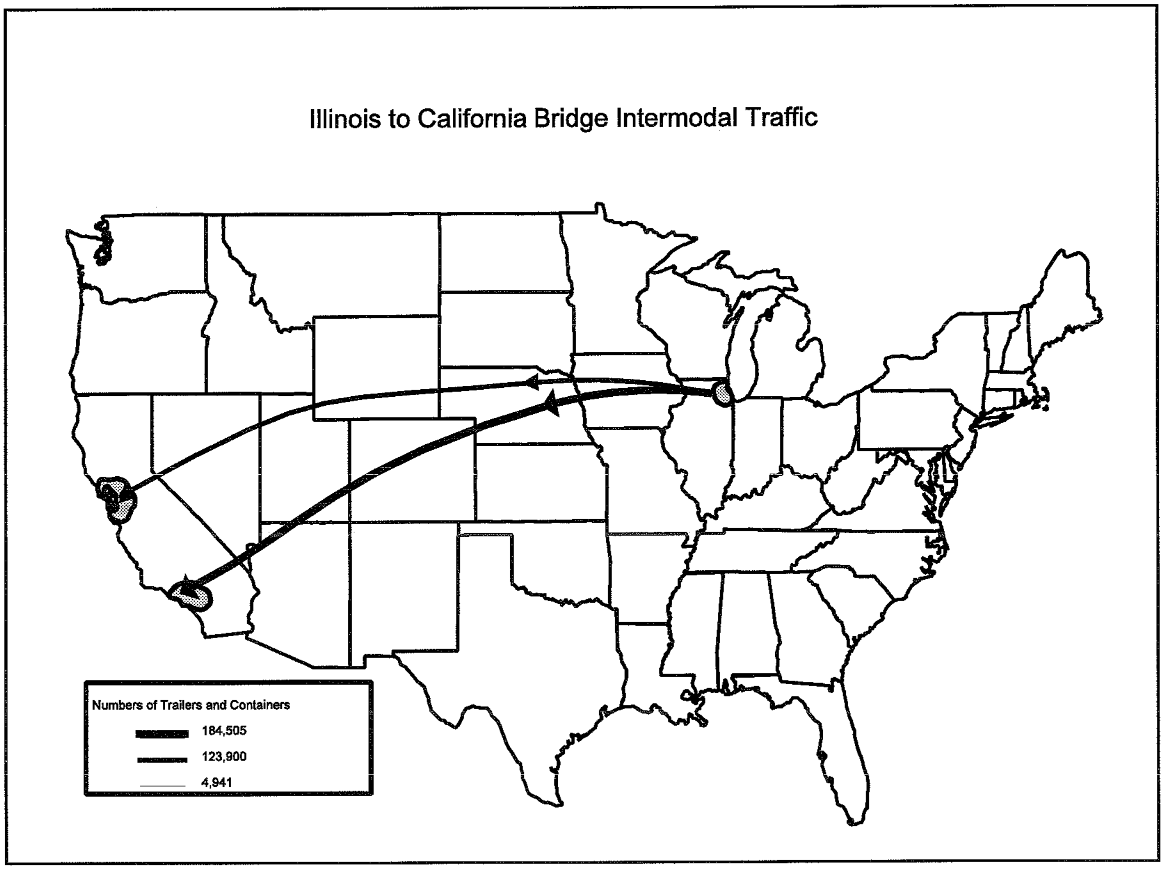

Figure 3-4 Intermodal Bridge Traffic Movements from Illinois to California

Table 3-19 Intermodal Bridge Traffic: Other Major Corridors

Origin\Destination	Chicago	Seattle	Portland	Fremont	Dallas	Kansas City	Denver	Sum	Percent †
Chicago		67,660	54,520	43,060	26,956	21,712	19,696	233,604	16.7
Dallas	10,160							10,160	0.7
Houston	10,031							10,031	0.7
Fremont, NE	19,664							19,664	1.4
Seattle	85,297							85,297	6.1
Kansas City	22,700							22,700	1.6
Sum	147,852	67,660	54,520	43,060	26,956	21,712	19,696	381,456	27.3
Percent †	10.6	4.8	3.9	3.1	1.9	1.6	1.4	27.3	

† Percent of total intermodal bridge traffic

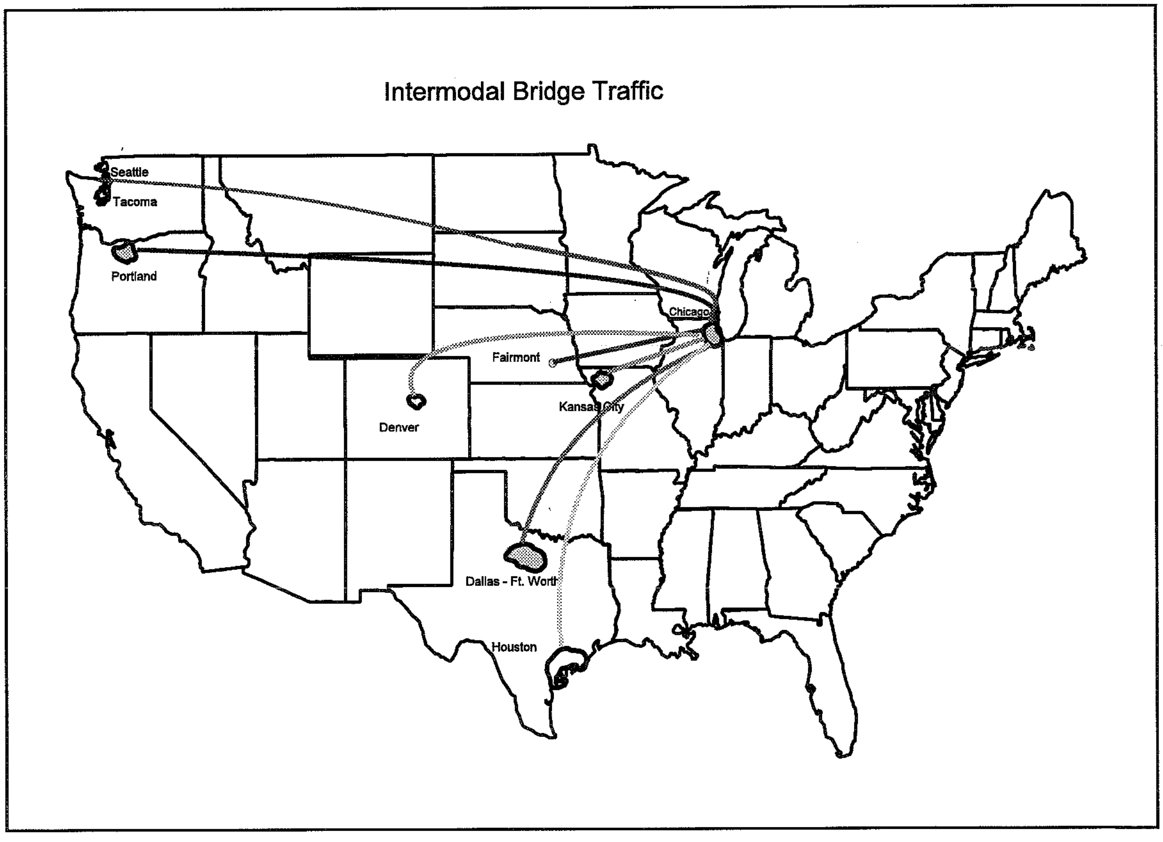

Figure 3-5 Major Intermodal Bridge Traffic Movements Other Than California

Railcar Traffic

Summaries of traffic shipped by rail were obtained from the 1989 confidential waybill sample. This summary identifies the major commodities shipped to and from the state of Iowa, based on the weight of shipments. Major commodity groups are later analyzed to determine the distribution of traffic among major origin-destination pairs.

Originating Traffic. A total of 24.3 million tons (excluding intrastate traffic) of all commodities were shipped in railcar from Iowa in 1989. Table 3-20 lists the commodities accounting for the majority of the tonnage. Field crops (corn and soybeans) accounted for 53 percent of the total traffic originating in Iowa. Food and kindred products was the second most frequent commodity shipped, accounting for 34.9 percent, followed by chemicals and allied products accounting for less than five percent. More than 42 percent of the shipments originating in Iowa in 1989 terminated in Illinois, while intrastate shipments amounted to about 29 percent, shipments to Missouri amounted to 11.7 percent , Louisiana 8.7 percent, California 5.8 percent, Minnesota 4.8 percent, Texas 4.7 percent, and Washington 4.1 percent. Shipments to these six states accounted for about 82.1 percent of the total commodities

Table 3-20 1989 Railcar Tonnage Originating in Iowa by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
1	Farm Products	12,903,313	53.0	53.0
20	Food and Kindred Products	8,494,076	34.9	88.0
28	Chemicals	1,067,612	4.4	92.4
32	Stone, Clay, and Glass Products	740,942	3.0	95.4
40	Waste and Scrap Materials	578,274	2.4	97.8
29	Petroleum and Coal Products	146,960	0.6	98.4
14	Nonmetallic Minerals	128,846	0.5	98.9
37	Transportation Equipment	86,817	0.4	99.3
33	Primary metal products	50,160	0.2	99.5
24	Lumber and wood products	43,320	0.2	99.7
35	Machinery, except electrical	34,260	0.1	99.8
26	Pulp, paper and allied products	17,200	0.1	99.9
Sum of listed commodities		24,291,797		
Total (all commodities)		24,323,556		

originating in Iowa. Table 3-21 lists terminating states accounting for one percent or more of the total tonnage originating in Iowa.

Table 3-21 1989 Railcar Tonnage Originating in Iowa by Destination (excluding intrastate traffic)

Destination State	Tonnage	Percentage	Cumulative Percentage
Illinois	10,298,943	42.3	42.3
Missouri	2,845,714	11.7	54.0
Louisiana	2,127,245		62.8
California	1,405,985	5.8	68.6
Minnesota	1,173,021	4.8	73.4
Texas	1,134,507	4.7	78.1
Washington	994,368	4.1	82.1
Wisconsin	476,556	2.0	84.1
Nebraska	409,102	1.7	85.8
Kansas	318,228	1.3	87.1
Tennessee	310,215	1.3	88.4
Sum listed states	21,675,873		
Total	24,323,556		

Terminating Traffic. The commodities most frequently shipped to Iowa in 1989 are shown in Table 3-22. The total tonnage terminating in the state equaled about 21.8 million tons (excluding intrastate tonnage). Coal accounted for the largest tonnage terminating in Iowa, more than 13 million tons, or about 61 percent of the state terminating tonnage. Chemicals and allied products was the second largest tonnage, at 12.1 percent, followed by farm products shipments of about 9.5 percent, followed by of the total tonnage terminating in Iowa. Nonmetallic minerals and pulp and paper products each accounted for 4.7 percent and 3.1 percent of the terminating tonnage respectively. The top five commodities terminating in the state accounted for more than 90 percent of the terminating tonnage. About 57 percent of the coal

Table 3-22 1989 Railcar Tonnage Terminating in Iowa by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
11	Coal	13,292,397	60.9	60.9
28	Chemicals	2,648,206	12.1	73.0
1	Farm Product	2,077,793	9.5	82.6
14	Nonmetallic minerals, except fuels	1,024,089	4.7	87.2
26	Pulp, paper and allied products	668,860	3.1	90.3
33	Primary metal products	430,932	2.0	92.3
24	Lumber and wood products, except furniture	414,580	1.9	94.2
20	Food	381,280	1.7	95.9
29	Petroleum and coal products	295,572	1.4	97.3
40	Waste and scrap materials	235,316	1.1	98.4
Sum (listed commodities)		21,661,014		
Total (all commodities)		21,825,805		

shipped to Iowa originated in Wyoming. Table 3-23 shows states with significant shipments to Iowa. Among the states with significant shipments to Iowa were Minnesota, Illinois, South Dakota, Texas, and Nebraska.

Table 3-23 1989 Railcar Tonnage Terminating in Iowa by Origin (Excluding intrastate traffic)

Origin State	Tonnage	Percentage	Cumulative Percentage
Wyoming	12,432,773	57.0	57.0
Minnesota	2,116,759	9.7	66.7
Illinois	1,128,351	5.2	71.8
South Dakota	869,488	4.0	75.8
Texas	489,484	2.2	78.1
Nebraska	449,279	2.1	80.1
Indiana	431,637	2.0	82.1
Kentucky	391,944	1.8	83.9
Florida	303,694	1.4	85.3
Missouri	295,020	1.4	86.6
Louisiana	287,664	1.3	88.0
Wisconsin	271,660	1.2	89.2
Kansas	222,212	1.0	90.2
	21,825,805		

Bridge Railcar Traffic. The commodities most frequently shipped through Iowa are shown in Table 3-24. There was more than 100 million tons of bridge railcar traffic across Iowa in 1989. Coal shipments accounted for the largest bridge tonnage, more than 60 percent. Other major commodities shipped through Iowa were chemicals and allied products, food and kindred products, and farm products accounted for more than 6 percent each. Table 3-22 shows the bridge tonnage through Iowa by origin and destination. It may be noted in the table, these shipments are very scattered, i.e. no significant concentration in terms of percentage of total bridge tonnage exists. However, since coal shipments dominated the bridge tonnage through Iowa, Wyoming serves as the origin of a good portion of these shipments. The origin and destination pairs listed in Table 3-25 accounted for only 75 percent of the total bridge tonnage.

Table 3-24 1989 Bridge Railcar Tonnage through Iowa by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
11	Coal	60,561,972	60.6	60.6
28	Chemicals and Allied Products	6,721,744	6.7	67.3
20	Food and Kindred Products	6,676,252	6.7	73.9
1	Farm Products	6,374,562	6.4	80.3
24	Lumber and Wood Products	3,731,580	3.7	84.0
33	Primary Metal Products	3,642,134	3.6	87.7
37	Transportation Equipment	3,138,110	3.1	90.8
10	Metallic Ores	2,486,728	2.5	93.3
26	Pulp, Paper, and Allied Products	2,019,140	2.0	95.3
32	Stone, Clay and Glass Products	1,425,384	1.4	96.8
14	Nonmetallic Minerals	1,238,974	1.2	98.0
29	Petroleum or Coal Products	1,073,659	1.1	99.1
Sum (listed commodities)		99,090,239		
Total (all commodities)		100,019,722		

Table 3-25 1989 Bridge Railcar Tonnage through Iowa by Origin and Destination

Origin State	Destination State	Tonnage	Percentage	Cum %
Wyoming	Missouri	13,013,068	13.0	13.0
Wyoming	Illinois	11,560,936	11.6	24.6
Wyoming	Minnesota	9,024,416	9.0	33.6
Wyoming	Wisconsin	8,463,540	8.5	42.1
Wyoming	Texas	5,208,604	5.2	47.3
Wyoming	Oklahoma	4,383,972	4.4	51.6
Montana	Illinois	2,673,504	2.7	54.3
Wyoming	Indiana	2,625,175	2.6	56.9
Minnesota	Utah	2,473,132	2.5	59.4
Wyoming	Louisiana	2,176,572	2.2	61.6
Wyoming	Arkansas	1,816,278	1.8	63.4
Oregon	Illinois	1,022,900	1.0	64.4
Wyoming	Nebraska	830,206	0.8	65.3
Pennsylvania	California	784,160	0.8	66.0
Nebraska	California	760,896	0.8	66.8
Nebraska	Illinois	748,666	0.7	67.6
Nebraska	Kansas	642,554	0.6	68.2
Michigan	California	632,760	0.6	68.8
Idaho	Illinois	621,480	0.6	69.4
Texas	Illinois	617,376	0.6	70.1
Indiana	California	604,984	0.6	70.7
North Dakota	Texas	572,613	0.6	71.2
California	Illinois	555,974	0.6	71.8
Nebraska	Missouri	524,148	0.5	72.3
Minnesota	California	519,076	0.5	72.8
Illinois	California	510,801	0.5	73.4
Minnesota	Illinois	472,175	0.5	73.8
Wyoming	Kansas	466,296	0.5	74.3
Minnesota	Texas	447,358	0.4	74.7
Missouri	Illinois	412,224	0.4	75.2
Sum (listed O-D pairs)		75,165,844		
Total (all O-D pairs)		100,019,722		

Intrastate Railcar Traffic. There were more than 9.8 million tons of intrastate railcar shipments in Iowa in 1989. The majority of these shipments were intrastate farm products (grain) movements, which accounted for more than 76 percent of the total intrastate tonnage, as shown in Table 3-26. Other significant intrastate shipments were food and kindred products (especially, grain mill products), nonmetallic minerals, and chemicals and allied products.

Table 3-26 1989 Iowa Intrastate Railcar Tonnage by Commodity

STCC	Commodity	Tons	Percent	Cumulative Percentage
1	Farm products	7,516,085	76.1	76.1
20	Food and kindred products	802,604	8.1	84.2
14	Nonmetallic minerals	604,577	6.1	90.3
28	Chemicals and allied products	528,040	5.3	95.6
32	Stone, clay, and glass products	128,660	1.3	96.9
40	Waste, scrap	114,620	1.2	98.1
11	Coal	89,608	0.9	99.0
24	Lumber and wood products	49,500	0.5	99.5
37	Transportation Equipment	35,822	0.4	99.9
29	Petroleum or coal products	12,244	0.1	100.0
Total		9,881,760		

TRUCK TRAFFIC ANALYSIS

Data on truck commodity flows were obtained from the 1989 and 1991 Iowa Truck Weight Survey. The survey is conducted by the Iowa Department of Transportation biannually in corporation with the Federal Highway Administration. The survey was conducted at 16 locations in 1989 and 1991. The location of data collection points are shown Figure 3-6. The weighing schedule is prepared so that each station is operated during the same periods as past years. Manual counts are performed every year, while weighing is done in odd years.(3) The locations of the survey are not ideal for a representative sample of truck traffic, but survey locations do cover most of the interstate highways in the state. Although truck weight is the focus of this survey, additional information on the shipment are recorded manually on standard forms corresponding to each truck. This information includes the commodity carried, the origin of the shipment, and the destination of the shipment.

The truck weight survey data were received from the Iowa Department of Transportation on paper survey forms and the data were coded for computer analysis. The weight data, which includes the vehicle classification (identified by vehicle type and the number and configuration of its axles) and the commodity codes are key punched into electronic format.

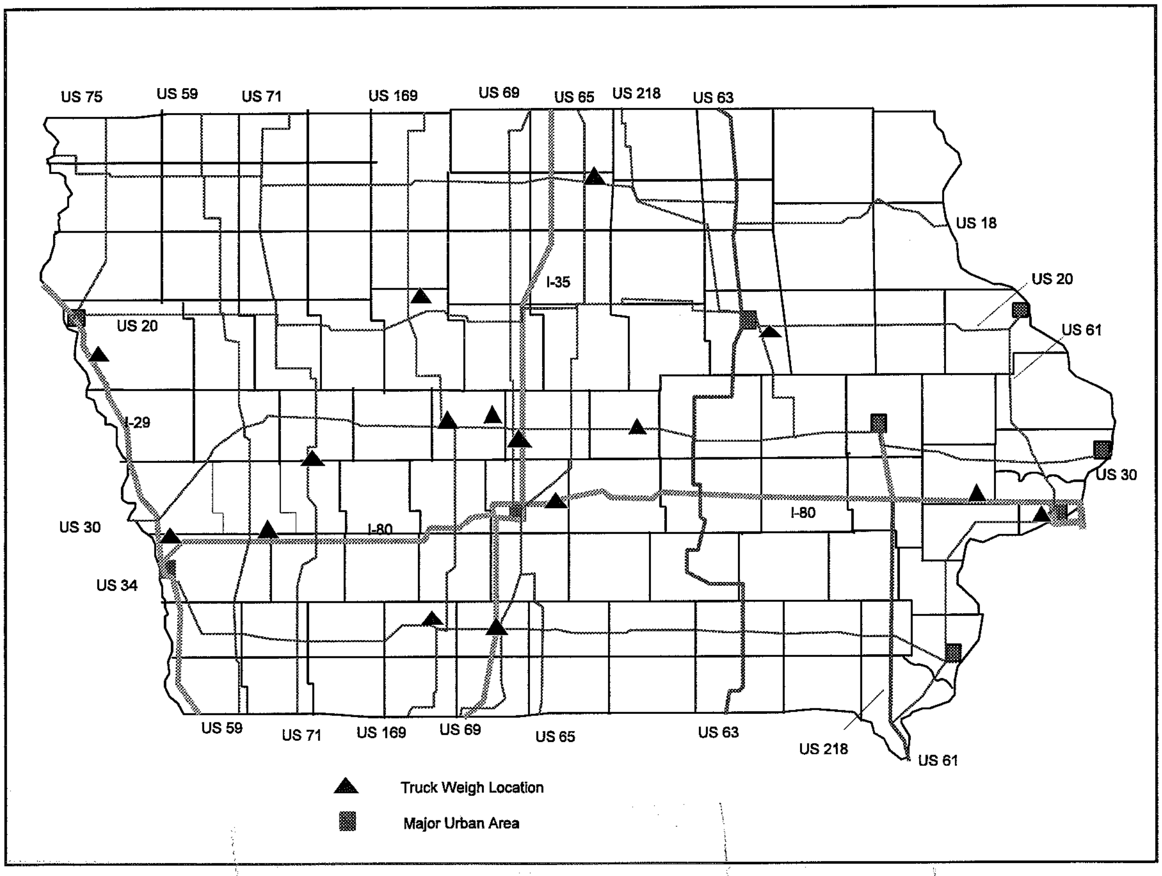

Figure 3-6 1989 and 1991 Iowa Truck Weight Survey Locations

The origin and destination information were added to the vehicle records in the computerized data base. The modified data are stored in PARADOX, a relational data base, which enables easy retrieval and analysis of this data. The main deficiency of data from the truck weight survey is its limited coverage. The survey is conducted during the summer months (May through August), during a short period (three seven-hour shifts for interstate locations, and two seven-hour shifts for all others). Sampling is done only once at each location, thus making it difficult to expand or extend the data to draw meaningful conclusions about truck commodity flows. Table 3-27 lists the locations of the survey and the 1989 proportion of observed trucks to the Average Daily Truck Traffic counts at the same locations. As can be seen in Table 2-27, the number of trucks actually surveyed is only a portion of the average number of trucks actually passing the location. Therefore, the results of the survey should be seen as being indicative of the relative traffic patterns. Survey results are only a snap shot of a portion of the traffic on the day the survey was conducted.

Table 3-27 Comparison of Observed Truck Traffic Count (ADT) at Truck Weigh Locations

		Number of Trucks		
Route	**County**	**Volume of Trucks Observed During Survey**	**Average Daily Truck Volume**	**Percentage of Average Volume Observed During Survey**
US-218	Black Hawk	57	149	38.3
US-65	Cerro Gordo	184	360	51.1
US-61	Scott	462	1,337	34.6
B20	Cerro Gordo	46	702	6.6
Local	Webester	52	N/A	
Local	Boone	75	N/A	
Local	Marshal	191	N/A	
IA-5	Marion	196	376	52.1
US-30	Boone	213	456	46.7
US-71	Carroll	147	196	75.0
US-34	Union	170	348	48.9
I-80	Polk	2,062	7,254	28.4
I-35	Story	1,647	3,519	46.8
I-29	Woodbury	1,077	1,781	60.5
I-29	Harrison	1,405	2,470	56.9
I-35	Clarke	1,405	2,542	55.3
Total Observations		9,389		

Originating Traffic. The total (unfactored) truck traffic originated in Iowa and destine to other states and surveyed at the truck weight locations in 1989 and 1991 was roughly 47,000 tons and 43,000, respectively. Tables 3-28 and 3-29 lists major commodities (accounting for 90 percent of the traffic) originating in Iowa. The commodities carried, the relative volume in each are very close. For example in both years, food and kindred products accounted for largest portion of total tonnage with 37 percent in 1989 and 38 percent in 1991. Of the 13 commodities that accounted for 90 percent of the traffic in 1991, eleven were the same commodities included in the 1989 list, although not always in the same order.

Table 3-28 1989 Iowa Originating Truck Traffic Destined Outside the State by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
20	Food and Kindred Products	17,302	36.8	36.8
1	Farm Products	5,094	10.8	47.6
41	Miscellaneous shipments	4,460	9.5	57.0
32	Stone, Clay, and Glass	3,053	6.5	63.5
35	Machinery, except	2,250	4.8	68.3
26	Pulp, Paper, and Allied	1,978	4.2	72.5
33	Primary Metal Products	1,955	4.2	76.7
24	Lumber and Wood Products	1,372	2.9	79.6
34	Fabricated Metal Products	1,082	2.3	81.9
91	Hazmat	1,003	2.1	84.0
37	Transportation Equipment	935	2.0	86.0
30	Rubber and Misc. Plastic	907	1.9	87.9
28	Chemicals and Allied	849	1.8	89.7
14	Nonmetallic Minerals	790	1.7	91.4
Total (All commodities)		47,083		

Table 3-29 1991 Iowa Originating Traffic Destined Outside the State by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
20	Food and kindred products	22,745	38.4	38.4
41	Misc. freight shipments	7,593	12.8	51.2
1	Farm products	5,309	9.0	60.1
32	Stone, clay and glass	3,074	5.2	65.3
35	Machinery except electrical	2,639	4.4	69.7
28	Chemical and allied products	2,300	3.9	73.6
33	Primary metal products	2,134	3.6	77.2
36	Electrical machinery	1,857	3.1	80.4
26	Pulp, paper and allied products	1,551	2.6	83.0
24	Lumber and wood products	1,352	2.3	85.3
46	Misc. mixed shipments	1,116	1.9	87.1
34	Fabricated metals	1,037	1.7	88.9
30	Rubber and plastic	1,023	1.7	90.6
Total (all commodities)		43,269		100

Probably one of the most significant changes in from 1989 to 1991 was an increase in electrical equipment shipments. In 1989 electrical equipment shipments accounted for 1.4 percent of the total volume, while in 1991 they accounted for 3.1 percent, a doubling. However, because of the limited coverage of the survey, interpretations made for changes in volumes may have no statistical validity.

Excluding intrastate shipments, the majority of the truck tonnage originating in Iowa terminated in neighboring states. Tables 3-30 and 3-31 list the percentages of total Iowa

Table 3-30 1989 Truck Tonnage Originating in Iowa by Destination

State	Tonnage	Percentage	Cumulative Percentage
Nebraska	7,582	16.1	16.1
Missouri	6,356	13.5	29.6
Illinois	6,169	13.1	42.7
Minnesota	5,552	11.8	54.5
Kansas	3,742	7.9	62.4
Texas	2,521	5.4	67.8
South Dakota	1,584	3.4	71.2
California	1,235	2.6	73.8
Wisconsin	1,210	2.6	76.4
Michigan	1,198	2.5	78.9
Ohio	893	1.9	80.8
Indiana	772	1.6	82.4
Arkansas	679	1.4	83.9
Florida	660	1.4	85.3
Oklahoma	601	1.3	86.6
New York	575	1.2	87.8
Pennsylvania	480	1.0	88.8
Georgia	434	0.9	89.7
Tennessee	430	0.9	90.6
Total (All States)	47,080		100

Table 3-31 1991 Truck Tonnage Originating in Iowa by Destination

State	Tonnage	Percentage	Cumulative Percentage
Nebraska	12,396	20.9	20.9
Illinois	8,855	14.9	35.9
Missouri	6,471	10.9	46.8
Minnesota	5,288	8.9	55.7
Kansas	4,173	7.0	62.8
Texas	2,993	5.1	67.8
California	2,001	3.4	71.2
South Dakota	1,725	2.9	74.1
Indiana	1,530	2.6	76.7
Wisconsin	1,201	2.0	78.7
Ohio	1,127	1.9	80.6
Colorado	882	1.5	82.1
Arkansas	848	1.4	83.5
Michigan	841	1.4	85.0
Oklahoma	777	1.3	86.3
Canada	716	1.2	87.5
New York	716	1.2	88.7
Tennessee	569	1.0	89.7
Florida	556	0.9	90.6
Total (All States)	59,239		100

originating traffic survey by destination state. The states adjacent to Iowa are the major destination for Iowa originating truck freight. In both 1989 and 1991 Nebraska, Illinois, Missouri, Minnesota, and Kansas received about 62 percent of all Iowa originating truck freight. States outside of the Midwest which receive significant portions of Iowa originating truck traffic are Texas and California. The destination of Iowa originating traffic is highly concentrated in the states adjacent to Iowa.

Terminating Traffic. About 47,000 and 61,000 tons (unfactored) were observed as terminating traffic in Iowa in 1989 and 1991, respectively, excluding intrastate shipments. The most frequently Iowa terminating traffic are listed by decreasing frequency in Tables 3-32 and 3-33. Food and kindred products accounted for the greatest portion in both years with roughly one-quarter of total tonnage. Although the order of the most frequent Iowa terminating traffic varies between 1989 and 1991, the commodities are almost identical.

Table 3-32 1989 Truck Tonnage Terminating in Iowa by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
20	Food and kindred products	10,858	23.1	23.1
41	Miscellaneous shipments	5,585	11.9	35.0
1	Farm products	4,574	9.7	44.8
26	Pulp, paper, and allied products	3,227	6.9	51.6
33	Primary metal products	3,210	6.8	58.5
28	Chemicals and allied products	3,100	6.6	65.1
24	Lumber and wood products	2,533	5.4	70.5
37	Transportation equipment	2,381	5.1	75.5
32	Stone, clay, and glass	1,972	4.2	79.7
35	Machinery, except electrical	1,589	3.4	83.1
91	Hazmat	1,286	2.7	85.9
14	Nonmetallic minerals	1,016	2.2	88.0
34	Fabricated metal products	793	1.7	89.7
25	Furniture and fixtures	680	1.4	91.2
29	Petroleum and coal products	561	1.2	92.4
36	Electrical machinery	482	1.0	93.4
Total (all commodities)		46,952		

Table 3-33 1991 Truck Tonnage Terminating in Iowa by Commodity

STCC	Commodity	Tons	Percentage	Cumulative Percentage
20	Food and kindred products	15,902	25.9	25.9
41	Misc. freight shipments	7,869	12.8	38.8
1	Farm products	5,511	9	47.8
28	Chemical and allied products	4,322	7.1	54.8
33	Primary metal products	4,137	6.8	61.6
26	Pulp, paper and allied products	3,764	6.1	67.7
24	Lumber and wood products	3,336	5.4	73.2
32	Stone, clay and glass	2,473	4	77.2
37	Transportation equipment	2,364	3.9	81.1
35	Machinery except electrical	1,639	2.7	83.7
34	Fabricated metals	1,265	2.1	85.8
29	Petroleum or coal products	1,098	1.8	87.6
46	Misc. mixed shipments	1,049	1.7	89.3
14	Nonmetallic minerals	1,029	1.7	91
Total (all commodities)		61,288		100

Tables 3-34 and 3-35 identify the most frequent states originating traffic which terminates in Iowa. Excluding intrastate traffic, the majority of shipments terminating in Iowa originates in the surrounding states. In both 1989 and 1991 roughly 55 percent of traffic terminating in Iowa originated in four surrounding states, Nebraska, Illinois, Kansas, and Missouri.

Table 3-34 1989 Truck Tonnage Terminating in Iowa by Originating State

Origin State	Tons	Percentage	Cumulative Percentage
Nebraska	8,435	17.9	17.9
Kansas	7,242	15.4	33.3
Illinois	5,449	11.6	44.9
Missouri	5,124	10.9	55.8
Minnesota	4,396	9.3	65.2
Texas	2,246	4.8	70.0
South Dakota	1,631	3.5	73.4
California	1,519	3.2	76.7
Wisconsin	1,417	3.0	79.7
Arkansas	1,319	2.8	82.5
Oklahoma	1,052	2.2	84.7
Ohio	1,005	2.1	86.9
Indiana	806	1.7	88.6
Michigan	775	1.6	90.2
Tennessee	468	1.0	91.2
Total (all origins)	47,018		

Table 3-35 1991 Truck Tonnage Terminating in Iowa by Originating State

Origin State	Tonnage	Percent	CumulativePercen
Nebraska	10,634	17.5%	17.5%
Illinois	10,311	17.0%	34.5%
Missouri	7,234	11.9%	46.5%
Kansas	6,292	10.4%	56.8%
Minnesota	4,389	7.2%	64.1%
Indiana	2,355	3.9%	68.0%
Texas	1,959	3.2%	71.2%
California	1,832	3.0%	74.2%
Wisconsin	1,676	2.8%	77.0%
Michigan	1,479	2.4%	79.4%
Arkansas	1,337	2.2%	81.6%
Ohio	1,199	2.0%	83.6%
Oklahoma	1,118	1.8%	85.4%
Canada	783	1.3%	86.7%
Pennsylvania	647	1.1%	87.8%
New York	584	1.0%	88.7%
Colorado	546	0.9%	89.6%
Connecticut	546	0.9%	90.5%
Total (all origins)	60,655		

Intrastate Traffic. The total observed intrastate truck tonnage in Iowa was 49,304 tons in 1989 and 43,269 in 1991. Intrastate traffic accounts for about 20 percent of all the truck traffic (bridge traffic accounts for nearly half of all traffic). Tables 3-36 and 3-37 lists the major intrastate tonnage by commodity for 1989 and 1991 respectively. Similar to railcar traffic, food and kindred products and farm products were the two main intrastate commodities. Food product intrastate shipments amounted nearly one-quarter of Iowa's intrastate tonnage, while farm products accounted for roughly 15 percent. The most frequently commodities hauled are roughly the same in both years although the order of the commodities by frequency varies.

Table 3-36 1989 Iowa Intrastate Truck Tonnage by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
20	Food and kindred products	11,087	22.5	22.5
1	Farm products	8,885	18.0	40.5
41	Misc. freight shipments	4,435	9.0	49.5
14	Nonmetallic ores	3,846	7.8	57.3
91	Hazmat	2,972	6.0	63.3
35	Machinery, except electrical	2,586	5.2	68.6
32	Stone, clay and glass products	2,500	5.1	73.6
33	Primary metal products	1,583	3.2	76.9
47	Small package freight	1,427	2.9	79.8
24	Lumber and wood products	1,273	2.6	82.3
37	Transportation equipment	1,179	2.4	84.7
34	Fabricated metal products	1,061	2.2	86.9
26	Pulp, paper and allied products	892	1.8	88.7
29	Petroleum or coal products	785	1.6	90.3
	Total (all commodities)	46,610		

Table 3-37 1991 Iowa Intrastate Truck Tonnage by Commodity

STCC	Commodity	Tonnage	Percentage	Cumulative Percentage
20	Food and kindred products	10,649	24.6	24.6
1	Farm products	5,974	13.8	38.4
41	Misc. freight shipments	4,892	11.3	49.7
14	Nonmetallic minerals	3,726	8.6	58.3
32	Stone, clay and glass	2,816	6.5	64.8
28	Chemical and allied products	1,753	4.1	68.9
35	Machinery, except electric	1,691	3.9	72.8
29	Petroleum and coal products	1,684	3.9	76.7
24	Lumber and wood products	1,091	2.5	79.2
26	Pulp, paper and allied products	1,047	2.4	81.6
33	Primary metals products	985	2.3	83.9
47	Small package freight	878	2	85.9
91	Hazmat	843	1.9	87.9
34	Fabricated metals	697	1.6	89.5
46	Misc. mixed shipments	659	1.5	91
	Total (all commodities)	43,269		100

Table 3-38 1989 Bridge Truck Tonnage Through Iowa by Commodity

STCC	Commodity	Tonnage	Trucks	Percentage	Cumulative Percentage
20	Food and kindred products	30,674	880	26.2	26.2
1	Farm products	12,770	351	10.9	37.2
41	Misc. freight shipments	12,665	434	10.8	48.0
33	Primary metal products	8,930	261	7.6	55.6
26	Pulp, paper and allied	8,456	254	7.2	62.9
28	Chemicals and allied products	6,885	207	5.9	68.8
24	Lumber and wood products	5,075	149	4.3	73.1
35	Machinery except electrical	4,345	167	3.7	76.8
32	Stone, clay and glass	3,942	130	3.4	80.2
37	Transportation equipment	3,547	138	3.0	83.2
34	Fabricated metal	2,404	86	2.1	85.3
25	Furniture and fixtures	2,010	97	1.7	87.0
36	Electrical machinery	1,954	76	1.7	88.7
29	Petroleum or coal products	1,902	54	1.6	90.3
	Total(all commodities)	116,892	3,683		

Table 3-39 1991 Bridge Truck Tonnage Through Iowa by Commodity

SPCC	Commodity	Tonnage	Trucks	Percentage	Cumulative Percentage
20	Food and kindred products	50,340	1457	26.1	26.1
41	Misc. freight shipments	27,155	918	14.1	40.3
1	Farm products	22,067	604	11.5	51.7
33	Primary metal products	12,954	382	6.7	58.4
26	Pulp, paper and allied products	11,375	357	5.9	64.4
28	Chemicals and allied products	10,767	328	5.6	70.0
24	Lumber and wood products	7,931	241	4.1	74.1
35	Machinery except electrical	7,475	363	3.9	78.0
37	Transportation equipment	6,705	253	3.5	81.4
32	Stone, clay and glass	6,452	222	3.4	84.8
36	Electrical machinery	4,447	174	2.3	87.1
25	Misc. mixed shipments	4,143	139	2.2	89.3
26	Furniture and fixture	3,116	145	1.6	90.9
	Total (all commodities)	192,506	6,324		100

Bridge Traffic. The commodities most frequently shipped by truck through Iowa in 1989 and 1991 are listed in Tables 3-38 and 3-39. More than one fourth of Iowa's bridge truck traffic is made up of food and kindred products during both 1989 and 1991. Farm products and miscellaneous freight shipments were the next most frequent shipped commodities. The sample shows a significant increase in traffic between 1989 and 1991. However, the growth observed maybe as much a result of random variation in traffic volumes observed through the rather small sample collected. However, at the same time truck traffic volumes on the interstate highways across Iowa has experienced strong grow during this period.

The majority of all trucks surveyed were hauling bridge traffic. In 1991, 54 percent of the truck surveyed were hauling bridge traffic, 17 percent were carrying goods destine to Iowa but originating in another state, 17 were haul goods originating in Iowa but destine to another state, and 12 percent of the trucks were involved in a interstate shipments. The sample was not designed to representative of all movements across the entire state. The sample does suggest the importance of bridge traffic across Iowa.

Table 3-40 and 3-41 list the percentage of bridge traffic by state of origin. In both years, roughly 60 percent of the bridge truck tonnage through Iowa has originated in bordering states, Minnesota, Nebraska, Kansas, Missouri, Illinois, Wisconsin and South Dakota. California and Texas both are major origins for truck shipments through Iowa. However, there is no evident concentration on a single or few corridors. In stead, truck traffic through the state is scattered from around the region. This is expected from typical truck shipments of shorter hauls.

Table 3-40 1989 Bridge Truck Traffic Tonnage by Origin State

Origin State	Tonnage	Percentage	Cumulative Percent
Minnesota	17,875	15.3	15.3
Nebraska	16,545	14.2	29.5
Illinois	10,109	8.7	38.1
Kansas	9,747	8.3	46.4
California	9,058	7.8	54.2
Wisconsin	8,284	7.1	61.3
Missouri	7,184	6.1	67.4
South Dakota	6,175	5.3	72.7
Texas	4,807	4.1	76.8
Colorado	2,599	2.2	79.1
Michigan	2,327	2.0	81.1
Arkansas	1,916	1.6	82.7
Oklahoma	1,723	1.5	84.2
Ohio	1,697	1.5	85.6
Idaho	1,609	1.4	87.0
Indiana	1,548	1.3	88.3
Canada	1,281	1.1	89.4
Pennsylvania	1,174	1.0	90.4
Total	116,854	100.0%	

To further explore bridge traffic patterns, the 1991 bridge traffic over Iowa from the four most frequent origin states, Illinois, Nebraska, Minnesota, and California, are listed in Tables 3-42, 3-43, 3-44, and 3-45. The bridge traffic originating in Illinois (Table 3-42) is largely destine to states in the region. Almost 15 percent, however, is involved in long haul movements to California. Roughly thirty percent of the Illinois to California traffic consists of food and kindred products, ten percent consists of chemical and allied products, and eight percent consists of fabricated metals. The remainder is spread across several commodity categories.

Table 3-41 1991 Bridge Truck Traffic Tonnage by Origin State

Origin State	Tonnage	Percentage	Cumulative Percentage
Illinois	25,276	13.9	13.9
Nebraska	21,378	11.7	25.6
Minnesota	19,182	10.4	36.1
California	17,654	9.7	45.8
Wisconsin	12,495	6.9	52.7
Missouri	12,049	6.6	59.3
Kansas	8,519	4.7	64.0
South Dakota	5,851	3.2	67.2
Colorado	5,462	3.0	70.2
Michigan	5,363	2.9	73.1
Texas	4,777	2.6	75.8
Indiana	4,600	2.5	78.3
Ohio	4,479	2.5	80.8
Oregon	3,337	1.8	82.6
Idaho	3,290	1.8	84.4
Washington	3,096	1.7	86.1
Pennsylvania	2,782	1.5	87.6
Arkansas	2,142	1.2	88.8
Oklahoma	1,824	1.0	89.8
Utah	1,798	1.0	90.8
Total	182,137	100.0%	

Table 3-42 Bridge Truck Traffic By Destination State Originating in Illinois

Destination State	Tonnage	Percentage	Cumulative Percentage
Nebraska	9,548	38	38
California	3,694	14.7	52.7
Missouri	2,140	8.5	61.2
Colorado	1,977	7.9	69
South Dakota	1,580	6.3	75.3
Kansas	1,397	5.6	80.9
Minnesota	891	3.5	84.4
Utah	832	3.3	87.7
Nevada	556	2.2	89.9
Texas	428	1.7	91.6
Total	25,144		100

Table 3-43 Bridge Truck Traffic By Destination State Originating in Nebraska

Destination State	Tonnage	Percentage	Cumulative Percentage
Illinois	6,471	30.3	30.3
Minnesota	2,164	10.1	40.4
South Dakota	1,989	9.3	49.7
Wisconsin	1,612	7.5	57.2
Ohio	1,372	6.4	63.7
Michigan	1,230	5.8	69.4
Indiana	1,218	5.7	75.1
Pennsylvania	939	4.4	79.5
Nebraska	639	3	82.5
New Jersey	538	2.5	85
Canada	441	2.1	87.1
New York	403	1.9	89
Missouri	332	1.6	90.5
Total	21,378		100

Bridge traffic originating in Nebraska (Table 3-43) is largely destine to states in the region. Bridge traffic originating in Minnesota (Table 3-44) is similarly destine to mostly states with in the region, however, the most frequent destination for Minnesota shipments is Texas. Significant volumes are also destine to Oklahoma and Arkansas. Nearly forty percent of the bridge traffic from Minnesota to Texas consists of food and kindred products, thirteen percent consists of miscellaneous freight shipments, and farm products, pulp, paper and allied products, chemical and allied products, and primary metal products each account for roughly six percent of the traffic. The remaining Minnesota to Texas shipments were spread across several commodity groups.

Table 3-44 Bridge Truck Traffic By Destination State Originating in Minnesota

Destination State	Tonnage	Percentage	Cumulative Percentage
Texas	3,534	18.4	18.4
Nebraska	3,492	18.2	36.6
Missouri	3,326	17.3	54
Kansas	2,040	10.6	64.6
Colorado	1,018	5.3	69.9
Illinois	908	4.7	74.6
California	888	4.6	79.3
Oklahoma	744	3.9	83.2
Arkansas	487	2.5	85.7
Tennessee	294	1.5	87.2
Arizona	284	1.5	88.7
Kentucky	236	1.2	89.9
Georgia	210	1.1	91
Total	19,182		100

Bridge traffic originating in California (Table 3-45) is destine to many points to the east of Iowa. Illinois is the most frequent destination for California shipments. A little over half of the shipment to Illinois consisted of farm products, presumably California fresh fruits and vegetables. Food and kindred products accounted for sixteen percent of the California to Illinois bridge traffic and miscellaneous freight shipments account for twelve percent. The remaining shipments were spread across several commodity groups.

Table 3-45 Bridge Truck Traffic By Destination State Originating in California

Destination State	Tonnage	Percentage	Cumulative Percentage
Illinois	4,866	27.7	27.7
Michigan	2,395	13.6	41.3
New York	1,483	8.4	49.7
Canada	1,392	7.9	57.6
Wisconsin	1,096	6.2	63.8
Minnesota	1,058	6	69.9
Ohio	920	5.2	75.1
Pennsylvania	904	5.1	80.2
Massachusetts	869	4.9	85.2
Indiana	680	3.9	89
New Jersey	553	3.1	92.2
Total	17,593		100

CONCLUSIONS

This chapter presented the freight transportation traffic data available for Iowa and an overview of the state's economic base. The paucity of the freight flow data and the lack of technical coefficients to convert economic data to transportation service requirements make it difficult to provide much other than a sketch of state's freight traffic. However, some of the properties that are important in characterizing freight flows in Iowa and economic activity supporting the demand for freight services include:

- There is a great deal of concentration in Iowa's manufacturing sectors, both respect to spacial distribution and with respect to distribution amongst the industrial sectors. Seventy-seven percent of all Iowa manufacturing employment is concentrated in seven economic sectors and the largest sector, food processing, accounts for roughly 20 percent of all employment. Further, most manufacturing is limited to few locations in the state, with exception of meat processing with is distributed throughout the state.

- Agricultural production is spread throughout the state. The spatial distribution of agricultural production will create difficulties when analyzing changes in agricultural commodity flows as a result of changes in transportation policy. However, because agriculture is dominated in the state by one predominate grain crop (corn), with one secondary crop (soy beans), diminishes the complexity of analysis. Further, in general, the flow through the transportation system is dictated by where the net revenues for corn and soy beans are the greatest. These rather simple routing rules and homogeneity of goods being transported should make policy analysis less complex.

- Intermodal traffic on Iowa's rail system is dominated by bridge traffic (traffic with neither a destination nor a origin in Iowa). Much of the nation's east-west bridge traffic passes through Iowa. Most of the bridge traffic is very long haul freight, with at least 36 percent of the bridge traffic involved in an international shipment and roughly 65 percent of all bridge traffic through Iowa having an origin or destination on the West Coast.

- Roughly 60 percent (by weight) of the rail car traffic destine to Iowa and through Iowa (bridge traffic) is coal, with the remainder of the traffic being other bulk commodities. Rail car traffic from Iowa to other states and intrastate is dominated by field crops (grain). The predominate destination for Iowa field crops is Illinois. Because the abundance of short haul field crops, the adoption of a broad network for intermediate doubles in Iowa and adjacent states could significantly reduce the grain haul by railroads intrastate and to locations in nearby adjacent states. The adoption of intermediate doubles would extend the cost effective range for trucking grain in comparison to shipping by rail.

- The truck traffic data analyzed in the chapter is a biased data sample. Data were all collected in July and most data were collected from trucks using interstate highways. Because of the time of the year of data collection and the location of data collection, field crops were probably under estimated and, because of the location of data collection, interstate transportation was probably over estimated. Nevertheless, the data are the best data available.

  Most of the truck traffic sampled were on a trip with an origin or destination in Iowa or state adjacent to Iowa. Much of the truck traffic was regional and the most common commodity carried by trucks was food and kindred products. Almost 55 percent of the trucks sampled were on a bridge trip but most trips (60 percent) originated in a state adjacent to Iowa. Roughly 60 percent of trips with either a destination in Iowa or an origin in Iowa involved a trip end in a state adjacent to Iowa. Although interstate truck traffic in Iowa was destine to location throughout the North America, it was most commonly moving within the region. In addition, 70 to 75 percent of the traffic carried by trucks was concentrated in six or seven commodity class where food and kindred products where always the most frequent commodities carrier.

ENDNOTES

1. Maze, T.H., Walter, C.K., Allen, B.J., Fuller, N., Hanson, M.., Maggio, M.E.. McGinnis, S., Smadi, A.G., and Svede, K., "The Changing Role of Freight Transportation Modes and Intermodal Freight Transportation," prepared for the Midwest Transportation Center, Iowa State University, Ames, Iowa, 1990, p.77.

2. Maze, T.H., Walter, C.K., Allen, B.J., Fuller, N., Hanson, M., Maggio, M.E., McGinnis, S., Smadi, A.G., and Svede, K., "The Changing Role of Freight Transportation Modes and Intermodal Freight," Midwest Transportation Center, Iowa State University, Ames, Iowa, 1990, p. 73.

3. Truck Weight Survey Instructions, Iowa Department of Transportation , Ames, Iowa, May 1987.

Chapter 4
Conclusions and Recommendations

The purpose of this report is to begin building a policy foundation for the analysis of the implications of a Longer Combination Vehicle (LCV) network in Iowa. One of the primary difficulties in conducting an analysis on LCVs is the variability of truck configurations and loads which are identified as LCVs, the variation of truck service markets served by each LCV configuration, and the variation in state regulations on vehicle configurations, axle loads, and dimensions; LCV network coverage; and LCV network access.

LCVs are generally defined as trucks which exceed one or more of the maximum vehicle dimensions identified by the Surface Transportation Assistance Act (STAA) of 1982. Because there are many possible truck configurations and vehicle loadings which would exceed the STAA maximum dimensions, there are many different configurations which are considered LCVs. Although the STAA of 1982 was intended to create a modicum of size and weight uniformity, states which historically permitted LCVs to operate on some portion of the state highway network were required to continue to permit operation of the same LCVs over at least the same portions of the state's highway network through a grandfathering clause. Later the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 froze existing LCV networks at their June 1, 1991, levels. During the freeze, Congress has the opportunity to examine new evidence on the performance and safety of LCVs and determine if a permanent freeze is warranted.

Because each state has defined their own LCV networks, frequently based on historical reasons, maximum vehicle dimensions are not commonly uniform from one jurisdiction to the next. Further, most regulation of vehicle safety, LCV network access, and vehicle operations are non-uniform from one jurisdiction to the next. As a result, it is difficult to draw any specific conclusions regarding LCVs given the tremendous variation in operation and regulation of this class of vehicles.

Assuming vehicle maximum size and weigh reforms are permitted, the issue is further confused by the possibility that none of the existing LCV configurations and current operating regulations are the most desirable for at least two reasons. One reason stems from the North

American Free Trade Agreement (NAFTA). If size and weight regulatory reforms are to be made, the reforms may favor the harmonization of standards with those of Mexico and Canada rather than adopting the standards of a jurisdiction currently permitting the operation of LCVs. Another primary reason relates to the basis used to promulgate current size and weight standards. Maximum axle loads, maximum gross vehicle weight, maximum vehicle length, and other regulated vehicle dimensions are, for the most part, based on prescriptive rules rather than on the science of how the vehicle will perform when it interacts with the roadway and with the rest of the roadway environment. Now that the science of vehicle dynamics is better understood, the issue of vehicle performance can be analyzed. As a result, it may well be that none of the historically adopted conventional or LCV vehicles are the most desirable configurations.

ISSUES PROMOTING SIZE AND WEIGHT REFORM

There are a number of issues which are promoting truck size and weight reform. Primarily, the motor carrier industry is interested in obtaining productivity gains through the expansion of maximum limits on truck size and weight. As truck and roadway technology has improved over the last six decades, maximum truck size and weight limits have increased (see Figure 1-3) and truck size has grown. Naturally, as the industry strives for greater productivity, it will continue to promote further size and weight reforms. Aside from the debate over the safety experience of LCVs, the motor carrier industry's desire for reform is supported by the generally positive results with LCVs in states where they are currently permitted to operate.

Although ISTEA temporarily froze the LCV network at its current size, pressure to expand the LCV network will begin anew following the LCV safety field tests unless these tests find LCVs to be unsafe. The likely pressure to expand the LCV network and the desire to harmonize size and weight regulation with Canada and Mexico will renew the debate on truck size and weight issues.

Another compelling argument is being made for an alternative approach to truck size and weight regulation based on the vehicle's pavement and bridge deterioration performance and on the vehicle's safety performance. Performance-based regulation assumes the purpose of size and weight regulation is to protect pavements and bridges from destructive axle loads and to protect highway users from vehicles that cannot be operated safely on existing highways (otherwise known as environment-related performance). For example, through the analysis of dynamic interaction between vehicles and pavements, it has been shown that the type of suspension, the number of axles, the air pressure in the truck tires, and the type of tires are as important to the level of pavement deterioration imposed by a vehicle as are gross weight or axle load.(1) Other research has looked at the environmental performance (safety) of the varying truck configurations, sizes, and weights.(2) It may be possible that regulation of performance characteristics of the vehicle rather than the prescriptive size and weight standards currently used would result in vehicles that cause less pavement and bridge deterioration, carry more freight, and operate more safely. For example, beginning in 1993 the United Kingdom has allowed trucks with "road friendly suspensions" to carry greater axle loads.(3)

The concept of performance-based size, weight, and configuration regulation is not new. One of the earliest suggestions to consider performance-based regulation in the United States appeared in a U. S. Department of Transportation report to Congress which was requested in the Surface Transportation Assistance Act of 1978. The report assesses various size and weight regulation approaches. One of the policy options proposed was to adopt performance-based size and weight standards.(4)

TRAFFIC VOLUMES

LCV traffic volumes that can be anticipated as a result of any expansion of an LCV network are likely to be a function of several LCV system supply variable and LCV truck service demand variables. The primary variables include:

LCV System Supply Variables

1. The vehicle configurations and size and weight limits allowed to operate on the expanded LCV network.

2. The extent and coverage of the of network and uniformity of the network with those of other states.

3. The access provided to the network.

4. Safety restrictions placed on the weather and environmental conditions in which LCVs may operate, fitness and experience of the drivers, and equipment condition.

LCV Truck Traffic Demand Variables

1. Carrier and shipper traffic densities along LCV corridors within the network.
2. Loading and unloading costs (logistics costs) associated with the use of the network.
3. The value and/or perishability of the goods being carried.
4. The connectivity between origins and destinations through the LCV network.

Although it may be possible to identify the limited number of supply variable scenarios, the demand variables are determined by a very large number of variables involving the location of economic activities, the transportation needs of the economic activities (both suppliers and consumers), and the distribution patterns of goods. The demand estimation issue is addressed in the report produced for the second phase of this project, which addresses the modeling of freight traffic demand and distribution and creates a model to examine the implications of changes made to the highway network.

POLICY ISSUES

Assuming the Federal Highway Administration's safety field tests find LCVs are safe or no less safe than conventional combination trucks and the federal freeze on LCVs is lifted by Congress, there are several policy issues states like Iowa will face when considering the expansion of an LCV network with their jurisdiction. Following are some of the likely policy issues.

Legal Issues

Iowa law is written to promote uniformity of maximum truck size and weight on all the state's public roads. The Code of Iowa identifies maximums which conform to the STAA of 1982 maximum dimensions for the National Highway Network. The code states "... the maximum size and weight of vehicles herein specified shall be lawful throughout this state, and local authorities shall have no power or authority to alter said limitations ..."(5) The intent of the law and philosophy of the state's size and weight regulations is to be uniform throughout the state on all roadways. An LCV network in Iowa would, undoubtedly, be limited to roadways of a certain classes with the appropriate roadway geometry and adequate pavements and hydraulic structures to support LCV traffic. A modification would be required to both state law and the philosophy of uniform regulation on all Iowa roadways.

Beneficiaries

Depending on technical decisions made with regard to LCV network system supply variables, some economic sectors will benefit more than others from an expanded LCV network. For example, a broad network for intermediate doubles with land access to the network throughout Iowa would benefit Iowa's agricultural sector and other bulk goods haulers (i.e., aggregate haulers, liquid haulers, etc.). A broad system for intermediate doubles would increase the amount of grain moved to processors and river terminals by trucks and diminish grain carried by rail. At the same time, such a system would place more stress on a rural highway system which is already suffering from a lack of investment. On the other hand, if an LCV network were restricted to the interstate system where turnpike doubles and triples were permitted, the beneficiaries would be interstate shipments across Iowa and interstate shipments to and from Iowa. The important policy issue to be considered is that the benefits of increased trucking productivity will not be uniformly accrued by all economic sectors, with those activities with greater access to LCV networks benefitting the most.

Policy makers should recognize that not all segments of the trucking industry will appreciate productivity gains equally. As a result, not all purchasers of transportation services will gain. Shippers that demand transportation service with characteristics compatible with the characteristics of LCV services will gain, while those with transportation needs that are not benefitted by LCVs or that have poor access to LCV services may not. Policy makers must recognize the unevenness of the benefits and realize the distribution of benefits will depend on the system's design.

One of the groups that will suffer disbenefits under any scenario is the railroad industry. However, under a scenario of a broad system for intermediate doubles it is likely traffic would be diminished only on local grain gathering lines and natural resources hauling lines. For example, light density branch lines and short line railroads in the eastern half of Iowa may lose significant traffic to intermediate doubles moving grain to river terminals and grain processors. Under the scenario where triples and turnpike doubles are limited to the interstate system, traffic diverted from railroads will be interstate shipments which are carried on mainlines. The estimates made by the railroad industry of net revenue losses are probably overstated. Given the relative efficiency of long haul tranportation by rail for bulk commodities (predominately grain and coal) and the cost advantages of rail in the intermodal market, it seems unlikely that losses will be as high as those predicted by the railroad industry.

An understanding of how LCV network supply decisions will impact the distributions of benefits should be useful in formulating system design policy.

Increased Infrastructure Costs and User Fees

LCVs are likely to result in the same or lower levels of damage to pavements in comparison to conventional trucks. It is not clearly understood, however, how much more damage will be imposed on bridges. In addition, under LCV network scenarios which involve turnpike doubles and triples, improvements must be made to the geometry of interstate interchanges, staging areas must be constructed, and other geometric improvements will be required in and around the interstate. Of course, the extent of these improvements will depend on the configurations and weights of vehicles permitted to operate on Iowa's highways. Nevertheless, the permit fees and registrations fees paid by LCV operators need to cover the incremental costs of these improvements.

Uniformity and Multijurisdictions Consideration

Chapter 1 identified the maximum dimensions of LCVs permitted by each LCV jurisdiction, clearly demonstrating that the dimensions of trucks allowed to operate under overdimensional nondivisible load permits vary from state to state. In some states, the maximum load of a vehicle is determined by the bridge formula rather then based on a unique gross load limit. As a result, the maximum gross load limit is based on specific axle spacing, configuration, and overall length. Estimates of the maximum gross load limit were based on calculations assuming likely vehicle dimensions, but maximum load will vary from one configuration to the next. Other states have clearly defined specific gross vehicle weight limits.

Such unpredictable variation in size and weight limits would need to be addressed to allow efficient LCV operation. If the LCV network is expanded, states should promote uniformity size and weight regulations between states within the region. In addition, groups of states within regions should support multi-state consortia where states permit and identify routes for one another.

CONCLUSIONS

An examination of the potential expansion of an LCV network or permitting of other non-conventional truck configurations cannot view LCVs as an independent portion of the trucking industry. The ability to offer services using non-conventional configurations provides motor carriers with more flexibility in the equipment they use to meet demands for transportation service. The expansion of the LCV network, or other size and weight regulatory reforms, will assist the motor carrier industry in employing equipment alternatives to maximize utilization of equipment and labor. Because relaxation of truck size and weight regulation will provide more options to motor carries but not a completely new set of services, estimating possible LCV traffic is dependent on understanding the demand for truck services and the nature of other services provided.

On the other hand, state highway agencies must ensure that costs due to infrastructure modifications to accommodate new truck configurations and the added deterioration of the infrastructure are paid for by the motor carrier industry through appropriate registration and permit fees and possibly other highway use fees. This also requires an understanding of the demand for truck services.

Understanding and being able to model the demand for truck services in general and estimating the potential truck traffic by various combinations is the subject of the second phase report. The second phase research specifies and estimates a model of the demand for truck services.

ENDNOTES

1. Gillespie, T.D., Karamihas, S.M., Sayers, M.W., Nasim, M.A., Hansen, W., Ehsan, N., and Cebon, D., "Effects of Heavy-Vehicle Characteristics on Pavement Response and Performance," National Cooperative Highway Research Program Report 353, National Research Council, Washington, D.C., 1993, pp. 49-51.

2. Seatman, P.F. "Overview of Dynamic Performance of the Australian Heavy Vehicle Fleet," Technical Working Paper No. 7, National Road Transport Commission, Melbourne, Victoria, Australia, 1993.

3. "Yearbook of Road Transport Law 1994," Freight Transport Association Limited, Kent, England, 1994, pp. 220-221.

4. "An Investigation of Truck Size and Weight Limits: Final Report of the Secretary of Transportation to the United States Congress pursuant to Section 161 of Public Law 95-599, the Surface Transportation Assistance Act of 1978," Report to Congress prepared by the U.S. Department of Transportation, Washington, D.C., 1981, pp S-4 - S-5.

5. Code of Iowa, Legislative Service Bureau, General Assembly of Iowa, Des Moines, Iowa, Section 321.452.

Appendix A

Survey for Longer Combination Vehicle Permit Holders

MIDWEST
TRANSPORTATION CENTER

DIRECTOR
194 Town Engineering
Iowa State University
Ames, Iowa 50011-3070
Telephone: 515/294-8103
FAX: 515/294-8216

ASSOCIATE DIRECTOR
227 South Quadrangle
The University of Iowa
Iowa City, Iowa 52242
Telephone: 319/335-6800

February 21, 1992

Carlton Enterprises, Inc.
4054 Hart Road, Box 466
Richfield, OH 44286

Dear Sir/Ma'am:

The Midwest Transportation Center is conducting a survey of longer combination vehicle (LCV) permit holders to learn from their experience. The enclosed questionnaire asks about your firm, equipment, commodities, and origins and destinations for LCV traffic. There are also some general questions about the effects LCVs may have had on rates and costs. Responses will be averaged for reporting; no individual respondent will be identifiable.

The collected data will form the basis for a report on LCV usage to be published by the Midwest Transportation Center, a consortium of Iowa State University and the University of Iowa. If you would like a summary of these findings, please include your name and address at the end of the completed questionnaire. A postage-paid envelope is provided.

Should you have any questions about this project, please call the Midwest Transportation Center at (515) 294-8103. Thank you.

Yours truly,

Tom Maze
Director
Midwest Transportation Center

C.K. Walter
Clyde Kenneth Walter
Associate Professor
Department of Transportation
and Logistics

Enclosures

/pjl

Midwest Transportation Center

SURVEY FOR LONGER COMBINATION VEHICLE PERMIT HOLDERS

1. What are the approximate percentages of each of the following freight categories carried by your firm?
   ____% For-hire less-than-truckload
   ____% For-hire truckload
   ____% Private carrier (owned and operated for benefit of the shipper)
   ____% Exempt carrier (usually for agriculture-related shipments, minimum regulation)

2. Did your firm operate LCVs in 1991?
   ☐ Yes (If "Yes," go to question 4)
   ☐ No

3. If you answered "No" in question 2, please briefly explain why you did not operate LCVs in 1991.

   ____

   ____

4. What specific combinations have been used by your firm? Check (✓) all that apply.

   ☐ Doubles: two 28-foot trailers behind a tractor.
   ☐ Triples: a tractor and three 28-foot (nominal) trailers.
   ☐ Rocky Mountain Doubles: a tractor and 45- or 48-foot trailer pulling a 28-foot trailer.
   ☐ Twin 48s or Turnpike Doubles: a tractor pulling two 48-foot (or 45-foot) trailers.
   ☐ Straight truck plus 28-foot trailer.
   ☐ Bulk product trailers.

5. What commodities are normally carried by your LCVs?

   ______________________ ______________________

   ______________________ ______________________

6. In what volumes are these commodities most often carried?
   ☐ Less-than-truckload
   ☐ Truckload

7. For these typical commodities and volumes of LCV freight, what are your three most frequent origin and destination pairs (by city and state) and typical rates (cents per CWT if LTL, flat-rate for TL) for each pair?

Origins	Destinations	Rates	Trailer Length

(over)

8. For the freight referred to in questions 5, 6, and 7, how has your LCV operation affected the typical rates (compared to non-LCV motor carriers)?
   - ☐ Higher
   - ☐ Lower
   - ☐ No significant difference

9. If the freight referred to in questions 5, 6, and 7 were not carried on your LCVs, it would probably be carried by which?
   - ☐ Standard tractor-trailer
   - ☐ Railroad
   - ☐ Air
   - ☐ Water
   - ☐ Intermodal (containers or piggyback)

10. Please answer the following based on your firm's cost comparisons of LCVs with other vehicles:

a. Labor costs
- ☐ LCV higher per vehicle mile
- ☐ LCV lower per vehicle mile
- ☐ No significant difference

b. Fuel costs
- ☐ LCV higher per vehicle mile
- ☐ LCV lower per vehicle mile
- ☐ No significant difference

c. Maintenance costs
- ☐ LCV higher per vehicle mile
- ☐ LCV lower per vehicle mile
- ☐ No significant difference

d. Insurance costs
- ☐ LCV higher annually
- ☐ LCV lower annually
- ☐ No significant difference

e. Equipment costs
- ☐ LCV higher annually
- ☐ LCV lower annually
- ☐ No significant difference

11. About how many people are employed by your firm full-time? _______

12. About how many owner operators work with your firm? _______

13. Are your employees represented by a bargaining unit? ☐ Yes ☐ No

14. Who in your company might we telephone to discuss cost information in more detail?

Name: ________________________________

Title: ________________________________

Telephone: (_____) - ________________________

15. If we should send a summary of results to the above address, check (✓) here: ☐

Please return the completed questionnaire in the enclosed postage paid envelope to:

Midwest Transportation Center
194 Town Engineering Building
Iowa State University
Ames, Iowa 50011

Thank you again for your assistance.