FINAL REPORT

Comparison of Interstate vs. Illinois Intrastate CMV Safety Inspection Requirements

Project VB-H1, FY 98

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16. Abstract

This project assesses the safety performance of commercial motor vehicles in the State of Illinois. The motivation for this study Was to assess if federal and state safety regulations, which until recently were different, let to differing outcomes in safety Performance. The basic premise employed in this study is that differences in impacts between the regulations should be measurable By means of a set of outcome measures. The study used numerous state and national data on motor carrier safety and vehicle Crashes. Between 1993 and 1997, both the CMV Fatality Rate and the CMV Fatal Crash Involvement Rate in Illinois dropped, Mirroring national safety trends. The Illinois CMV Crash Involvement Rate (for all crashes) is somewhere between the light and Heavy truck crash rates at the national level. Inspection rates (per million miles driven) are higher for interstate CMVs compared to Intrastate CMVs. Drivers of interstate vehicles registered in states other than Illinois incurred the greatest Drive Out-Of-Service (OOS) rates. The highest rate of Vehicle OOS are by intrastate vehicles registered in Illinois. Further, vehicles that were subject to more stringent inspection standards are less likely to be involved in crashes subsequently than those subjected to less stringent standards. A much greater percent of vehicles incurring more than a certain "threshold" number of inspection violations (12 or more) are likely to be involved in crashes. The percent of interstate CMVs incurring zero violations in Illinois that are subsequently involved in crashes (in Illinois and other states) is different from the percent of intrastate CMVs with zero violations. The median probability of being involved in a crash following an inspection is only slightly different for vehicles inspected in Illinois that belong to all four types of carriers, namely Illinois interstate carriers, Illinois intrastate carriers, Non-Illinois carriers and Non-Illinois intrastate.

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Executive Summary
Comparison of Interstate vs. Illinois Intrastate CMV Safety Inspection Requirements

Safety is a critical element of the highway system. The study *Comparison of Interstate versus Illinois Intrastate CMV Safety Inspection Requirements* is intended to assess the safety performance of commercial motor vehicles in the State of Illinois. The motivation for this study was to assess if federal and state safety regulations, which until recently were different, led to differing outcomes in safety performance. The basic premise employed in this study is that differences in impacts between the regulations should be measurable by means of a set of outcome measures.

I. Objectives: The following research objectives were considered in the study: (i) to provide a descriptive summary of Illinois intrastate and interstate truck safety violations and crash patterns (ii) to determine the extent of difference, if any, between the safety performance of interstate Commercial Motor Vehicles (CMVs) and Illinois intrastate CMVs (iii) to evaluate relevant crash, inspection violation and exposure databases in terms of their usefulness in analyzing the differences (iv) to create linked databases relating to truck safety violations and crashes in Illinois, to document the properties of these databases and to create the necessary computer programs so that it becomes possible for future CMV safety trends to be monitored effortlessly.

II: Data Sources Used: Lack of timely, consistent and complete data is a major concern in the ability of enforcement agencies in making effective decisions about motor carrier safety. Numerous State of Illinois and national level data were used for this study. A starting point in using this data was to develp appropriate operational definitions of interstate and intrastate CMVs and interstate and intrastate carriers.

There were two primary classes of data used: those on safety performance of motor carriers and vehicles and those on exposure (or miles driven) by carriers and vehicles. The main purpose of using these various types of data was not to find out what the individual pieces say about safety, but what the entire profile of a carrier or a vehicle indicate about its safety performance. The data were linked together using innovative logic and computer coding. The end results are linked databases that allowed the safety performance of individual vehicles to be tracked over time and over multiple jurisdictions in the United States.

III. Methodology: The study compared the safety performance of interstate and intrastate CMVs using a set of core outcome measures. These included crash rates, fatality rates, inspection violation rates, and rate of inspection on a per mile basis. However, due to data limitations, crash rates and fatality rates by category of CMVs (that is, interstate and intrastate) could not be estimated. Using statistical methods, the percent of interstate and intrastate CMVs that were involved in crashes after being inspected was estimated. Further, a vehicle safety index, that uses information on the vehicle's crash and inspection violation history, the characteristics of the carrier and approximate

annual miles driven by the vehicle, was estimated.

IV. Summary of results: The results of this study can be grouped into two categories: those relating to the analysis of safety performance of interstate and intrastate CMVs and those relating to enhanced information-gathering and data management.

A. Safety performance analysis:

1) Fatality and crash rates: Between 1993 and 1997, both the CMV Fatality Rate and the CMV Fatal Crash Involvement Rate in Illinois dropped, mirroring national safety trends. The Illinois CMV Crash Involvement Rate (for all crashes) is somewhere between the light and heavy truck crash rates at the national level. However, due to data limitations, the breakdown of these estimates by interstate and intrastate CMVs could not be obtained.

2) Rate of inspection and inspection violation rates: Inspection rates (per million miles driven) are higher for interstate CMVs compared to intrastate CMVs. In the five years of inspection data analyzed, about 54% of the vehicle units (power unit and trailer) inspected are Non-Illinois CMVs. Together with Illinois interstate vehicle units analyzed, inspections of all interstate vehicle units constituted almost 75% of all inspections.

Drivers of interstate vehicles registered in states other than Illinois incurred the greatest Driver Out-Of-Service (OOS) rates. This is probably related to the violation of the hours of service regulations imposed on drivers. Interstate drivers drive long distances. Very often, there are no rest stations within easy proximity of the freeway for large interstate trucks to pull into, in order to satisfy hours of service regulations. The highest rate of Vehicle OOS are by intrastate vehicles registered in Illinois.

3) Safety performance of inspected vehicles: Vehicles that were subject to more stringent inspection standards are less likely to be involved in crashes subsequently than those subjected to less stringent standards. Vehicles subject to the most rigorous roadside inspection standard, the Level I standard, appears to be subsequently involved in crashes at a lower rate than vehicles subject to Levels II, IV and V. This indicates that Level I inspections are very valuable in lowering crashes.

There is essentially little difference in the percent of vehicles involved in crashes (within Illinois and in other states) up to a certain number of violations uncovered during inspection of the vehicles in Illinois. However, a much greater percent of vehicles incurring more than a certain "threshold" number of inspection violations (12 or more) are likely to be involved in crashes. Of all the vehicles that incurred 12 or more violations, almost 58% were vehicles belonging to Illinois interstate carriers, 22% to Illinois intrastate carriers, 18% to Non-Illinois interstate carriers and 2% to Non-Illinois intrastate carriers. The mean number of violations of vehicles involved in crashes is actually slightly lower than those not involved in crashes – at 1.57 compared to 2. However, it is the higher end of the tail of the distribution of number of violations that makes a difference with the percent involvement in subsequent crashes.

The percent of interstate CMVs incurring zero violations in Illinois that are subsequently involved in crashes is different from the percent of intrastate CMVs with zero violations. Roughly 2% of the trucks belonging to interstate carriers which incurred zero violations during inspections are involved in crashes within a year of the inspection. However, about 4% of the intrastate carrier vehicles which incurred zero violations are involved in crashes within a one year time period after the inspection. This points to the fact that vehicles belonging to intrastate carriers operate under conditions that offer greater potential for crashes compared to interstate carrier vehicles, which leads to a higher percent of vehicles involvement in crashes for vehicles that cleared the appropriate safety checks during inspections.

The median probability of a subsequent crash is only slightly different for vehicles inspected in Illinois that belong to all four types of carriers, namely Illinois interstate carriers, Illinois intrastate carriers, Non-Illinois interstate carriers and Non-Illinois intrastate. However, the range of probability of crashes differ. The distribution of crash probabilities for vehicles belonging to Non-Illinois interstate carriers is wider than for the other types of carriers. The median crash probability is also slightly higher for Non-Illinois interstate carriers, compared to the others.

B. Database-related analysis: The commercial vehicle data reporting and evaluation process in the United States needs to be enhanced. Currently, the data are decentralized, with crashes and inspections of intrastate carriers remaining with state-level entities and with subsets of the data on interstate carriers reported to federal databases. Further, states are lagging behind in the reporting of crash and inspection data to the Federal Motor Carrier Safety Administration's data systems. Current Intelligent Tranportation System (ITS) technologies may be thoroughly investigated to make, as much as possible, the entire process of updating inspection records and crash records, as paperless as possible. Further, the process of data dissemination needs to be made quicker and easier. Moreover, the data on carriers should be updated more frequently. Data on intrastate carriers are not available and again, limited data available at the state level has to be obtained. A stumbling block in obtaining consistent profiles of CMV safety is that various definitional differences exist among the different databases in terms of what constitutes a truck and what constitutes a certain type of carrier. Commonly accepted definitions that meet all or most safety monitoring standards are needed.

Much needs to be done in the area of exposure measures. The International Registration Plan (IRP) data must be made available to researchers. The MCS-150 form, which surveys mileage, with more frequent surveys, will also allow carriers to update their fleet mileage.

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Chapter 1

Problem Statement

1.1 Introduction

Safety issues concerning Commercial Motor Vehicles (CMVs) have received substantial interest in the last decade from researchers, politicians and the media. There is a desire among the public to have safer trucks. This study is intended to examine one aspect of the broad CMV safety issue – if there are differences in the crash rates and inspection violation rates among two different types of motor carrier firms and two different categories of commercial motor vehicles.

Until recently, there were differences in safety regulations as they apply to CMVs involved in interstate commerce and those serving intrastate commerce within Illinois. These differences pertain to (i)the number of times interstate and Illinois intrastate CMVs are safety-inspected per year, (ii) requirements of drivers to keep records of reported and perceived vehicle defects or deficiencies and (iii) driver examination of the latest report for the subject vehicle as part of the pre-trip preparation.

The State of Illinois recently adopted new motor carrier safety regulations. One of the major changes that occurred with the adoption of new Illinois standards is that whereas previously, drivers of intrastate trucks were not required to keep daily driver reports, at the current time, they are required to do so. Further, previously, the hours of service that a driver could incur driving an intrastate truck was longer than the hours of service that could be incurred by an interstate truck driver. Now the hours of service regulations are the same.

The federal commercial vehicle safety regulations clearly state that interstate trucks will always be subjected to the safety standards and regulations of the state in which they were operating at the time, in a manner that is "relative" to the state's safety regulations. If the state safety standards

are more stringent than the federal standards, then the local standards apply to the interstate truck operating in that state. If the federal standards are more stringent, then the interstate truck is subjected to the more-stringent federal standards. Part 392 titled *Driving of Commercial Motor Vehicles*, Subpart A General, Section 392.2 on *Applicable operating rules* (page 212) of the Federal Motor Carrier Safety Regulations Pocketbook states that:

> Every commercial motor vehicle must be operated in accordance with the laws, ordinances and regulations of the jurisdiction in which it is being operated. However, if a regulation of the Federal Highway Administration imposes a higher standard of care than that law, ordinance or regulation, the Federal Highway Administration regulation must be complied with.

1.2 Research Objectives

This study investigates whether the differing state and federal legislations led to differing levels of safety performance of interstate and intrastate trucks. The fundamental research premise of this study is that the differences in regulatory programs and practices pertaining to interstate and intrastate CMVs are identifiable (and measurable) through a set of outcome measures. These outcome measures are inspection violation rates of interstate and intrastate carriers and commercial vehicles and their crash rates. In addition, interstate and intrastate commercial motor vehicles are also compared on the basis of their relative risk of crash.

The study also critically examines the sources of data on the basis of which such studies are typically based on, including those which have been used for the current study. The safety history of commercial motor carriers and vehicles are recorded in numerous databases. As a result of the study, numerous databases were linked together, so that the safety performance of individual vehicles could be tracked over time and over different state boundaries.

The study, in summary, addresses the following targeted research objectives:

1. To provide a descriptive summary of Illinois intrastate and interstate truck safety violations and crash patterns in Illinois.
2. To determine the extent of difference, if any, between the safety performance of interstate CMVs and Illinois intrastate CMVs.
3. To evaluate relevant commercial motor vehicle crash, inspection and exposure databases in terms of their usefulness in analyzing the differences.
4. To create linked databases relating to truck safety violations and crashes in Illinois, to document the properties of these databases and to create the necessary computer programs so that it becomes possible for future CMV safety trends to be monitored effortlessly.

1.3 Analysis Approach

The analysis undertaken in this study utilized a rigorous data analysis and statistical modeling approach. The study used numerous databases linked together to produce meaningful indices of motor carrier and vehicle safety. Various national databases and State of Illinois databases were linked to "track" the safety performance of trucks over time and over state boundaries. The safety databases considered includes crash data, roadside inspection data and carrier (or commercial motor vehicle firm) data. In any safety study, the level of the "exposure" or risk posed by different entities being investigated must also be known. Most safety rates express exposure or risk in terms of Vehicle Miles Traveled (VMT). This was also the approach used in this study. For estimating VMT of the different entities being analyzed, various state and national level data sources were linked. Integrated, multi-year data of this nature allow analysts to objectively determine the level of risk posed by the entities whose safety performance is being investigated.

The study attempted to develop various indices to assess safety differences between interstate and intrastate carriers and vehicles. These include crash rates, inspection violation rates and a combined safety index. The safety index was developed, for each individual vehicle considered, on the basis of its crash history, inspection violation history and the safety history of the carrier or firm which owns the vehicle.

The period of analysis was the years 1993 through 1997. However, it was not possible to obtain all types of data for that entire five year period.

On the basis of such analysis, the study makes various recommendations for improving motor carrier safety. The recommendations are divided into two categories: those pertaining to making improvements in database development and linking to track safety history of motor carrier/vehicles and those relating to policy and operating conditions of safety enforcement approaches.

1.4 Organization of the Report

The report is organized as follows: Chapter 2, provides background information on truck safety trends and a detailed review of the literature on motor carrier safety on a limited number of important aspects. This Chapter also provides a summary description of the relevant databases available for commercial motor carrier/vehicle safety analysis. Chapter 3 provides an in-depth review of the databases used in the study, the objectives of linking databases, the results of data linking and the limitations of the databases. Chapter 4 describes the research methodology utilized in the study. Methodological questions include the approach used to estimate miles traveled by interstate and intrastate trucks and the outcome measures used to compare safety performances of interstate and intrastate trucks. The outcome measure include inspection violation rates, crash rates and the risk levels of trucks. Chapter 5 describes the estimated exposure rates or miles traveled by interstate and intrastate vehicles. Chapter 6 presents the results of the analysis of safety differences between the

two comparison groups. Chapter 7 summarizes the main results, in terms of the objectives of the study. The recommendations of the study are given in Chapter 8.

The main body of the report is followed by a series of appendices. Appendix A describes the different definitions of trucks used in the United States. Appendix B describes the Federal and State of Illinois commercial vehicle safety regulations. Appendix C provides a detailed discussion of all the databases that may be used by researchers to conduct analysis of motor carrier/vehicle safety. Appendix D describes the details of the linking different safety databases and provides the data dictionaries for the different linked databases that resulted from the study.

Chapter 2

Literature Review

2.1 Structure of the literature review

This chapter will review the relevant literature on motor carrier safety. Prior studies have shown that truck safety is increasingly becoming an important safety issue. Many factors influence truck safety including driver performance, roadway design and conditions, weather, vehicle performance, as well as motor carrier regulations and enforcement. The Federal Highway Administration (FHWA) published a Comprehensive Truck Size and Weight Study in 1997 which grouped the variables influencing overall truck crash risk into three main categories (a) truck equipment (b) driver performance and (c) operating environment (e.g., roadway and weather conditions). Many different governmental entities maintain safety-related data on motor carriers and trucks. A comprehensive study should consider many of these databases in a linked fashion to obtain the most meaningful insight on truck safety trends.

The chapter is organized as follows: in Section 2.2, we review overall highway safety trends, including the role of truck safety in these trends. In Section 2.3, we review related studies on truck safety. In section 2.4, we summarize a review of the types of databases that are currently available to analyze motor carrier and vehicle safety.

2.2 Review of Highway and Trucking Safety Trends

Over several decades, the safety statistics on U.S. roads have shown a positive pattern. Table 2.1 shows the improvements in the fatality rates [per 100 million Vehicle Miles Traveled (VMT)] on

U.S. highways. The decline in fatality rates have been consistent since 1940, especially since the inauguration of the Interstate Highway System in 1956. Improvements in safety have continued despite growth in population and an increase in the number of registered vehicles and licensed drivers.

Table 2.1: **Fatality rate in the United States over time**

Year	Fatality Rate per 100 million Vehicle Miles Travelled (VMT)
1940	11.4
1950	7.6
1956	6.0*
1960	5.3
1970	4.7
1980	3.3
1990	2.1
1996	1.7

* Beginning of the Interstate System.

Source: Highway Safety. On line. Internet: http://www.ohs.fhwa.dot.gov/info/saffacts.html

The fatality rate per 100 million Vehicle Miles Traveled (VMT) also compares favorably to that in most other counties. The selection of countries considered in Table 2.2 shows that highways in the United States, in 1995, were safer in terms of fatality rate than the others.

Table 2.2: **Comparative fatality rate in selected countries**

Country	Fatality rate per 100 million Vehicles Miles Travelled (VMT)*
USA	1.73
France	2.74
Canada	1.91
Germany	2.80
Japan	2.41
Mexico	15.70

* 1995 comparisons except for Canada, Germany and Mexico (1994)

Source: Highway Safety.

But improvement in highway safety remains a top priority with the federal and state transportation departments because the number of fatalities have remained high (at more than 40,000 deaths per year during the 1994 to 1996 period) (FHWA, 1998). Table 2.3 summarizes recent data on fatalities.

The greatest number of fatalities have occurred to occupants of motor vehicles. The number of fatalities in crashes involving large trucks has remained at about 5,000 during that period.

Table 2.3: **Recent highway fatality and other safety estimates**

	1994	1995	1996
Fatalities			
Total fatalities in all highway crashes	40,716	41,798	41,907
Motor vehicle occupant fatalities	34,293	35,274	35,579
Pedestrian fatalities	5,472	5,585	5,412
Pedalcyclist fatalities	802	830	761
Fatalities in single vehicle crashes	21,901	22,743	22,522
Fatalities in crashes involving large trucks	5,144	4,903	5,124
Fatalities at public highway-rail crossings	574	524	449
Fatal crashes			
Total number of fatal crashes	36,223	37,221	37,351
No. of single vehicle fatal crashes	20,526	21,245	21,046
No. of fatal crashes involving large trucks	4,373	4,178	4,396
Vehicle Miles Traveled			
Total VMT (in millions)	2,359,984	2,422,775	2,468,584*
Total Truck VMT (in millions)	170,415	179,497	–**

* Preliminary data.

** Not yet available.

Source: Highway Safety.

2.2.1 Trends in Trucking Industry

The safety aspects of motor carrier vehicles have been the focus of substantial regulatory and research interest in recent years. With the increased economic growth that the U.S. has witnessed in the last decade, the amount of freight to be moved has increased substantially. Figure 2.1 shows the relationship between freight demand, Gross Domestic Product (GDP) and goods production. The rate of change in ton-miles closely mirrors the rate of change in GDP.

In 1993, measured both by shipment value (72%) and by tonnage (about 53%),Space trucking was the most important mode of commodity shipment [Bureau of Transportation Statistics (BTS), 1998]. Trucking alone accounted for 25% of total revenue ton-miles of freight compared to 19.4% in 1983 and 19.8 in 1973 (U.S. Department of Transportation 1995). Since trucking is essentially a derived demand [related to the goods component part of the (GDP)], as the economy remains strong, there

may be continued rise in truck traffic. The share of truck traffic in most major metropolitan areas have increased substantially in recent years. In the Chicago area, for example, it has been estimated that truck traffic increased at a faster rate than any other class of traffic (Urban Transportation Center, University of Illinois at Chicago, 1999).

2.2.2 National Truck Safety Trends

During this period of large increases in truck traffic, there have been several high-profile crashes involving large trucks in the U.S. Large trucks were involved in 2.4% of all crashes leading to injuries in 1997 and 4.3% of all crashes leading to property damage [Office of Motor Carriers (OMC) of the Federal Highway Administration (FHWA), now known as the Federal Motor Carrier Safety Administration, 1998]. However, the percent share of large trucks in fatal crashes is much higher (about 8.5%). Governmental action as a response to this issue is greater funding for law enforcement, both at the roadside as well as for carrier (firm) safety management principles.

Table 2.4 provides some comparative statistics on aggregate (national-level) fatality and crash rates of trucks and passenger vehicles from 1993 to 1997. The data were compiled by OMC (1998) from three leading sources of safety statistics: the Fatal Analysis Reporting System (FARS), 1988-1997, General Estimates System (GES) 1988-97 and Highway Statistics, 1988-1997. There was a 7% decrease in the number of large trucks involved in fatal crashes from 1988 to 1992; this rate is similar to the percentage decrease (of about 7%) for passenger vehicles involved in fatal crashes. However, after an initial period of decline in trucks involved in fatal crashes (from 5,241 in 1988 to 4,035 in 1992), the number of fatal crashes involving large trucks have increased about 21% (from 4,035 in 1992 to 4,871 in 1997). But even though the count of crashes have increased during the 1992 to 1997 period, fatal crash rate (the number of fatalities per 100 million miles) involving large trucks have remained relatively constant simply because the miles traveled by trucks have increased as well, during this period. It was concluded in an U.S. General Accounting Office (GAO, 1999) report that if these mileage trends continue, the annual number of fatalities could increase to 5,800 in 1999 and continue to beyond 6,000 in the year 2000.

Injury crash rates declined by about 25% for large trucks while the decrease for all passenger cars involved in crashes was somewhat lower (about 14%). The number of passenger vehicles involved in injury crashes is about 30 to 40 times the number of injury crashes involving large trucks during the 1993 to 1997 period.

Trucks involved in crashes vary substantially by the type of vehicle configuration and by the Gross Vehicle Weight. Appendix A gives the Motor Vehicle Manufacturers Association categorization of trucks. About 63.5% of trucks involved in fatal crashes in 1997 were tractor/semi-trailers (OMC, 1998), followed by single-unit truck with two axles (10.9%). Also, about 78% of trucks involved in fatal crashes had GVW of over 26,000 pounds.

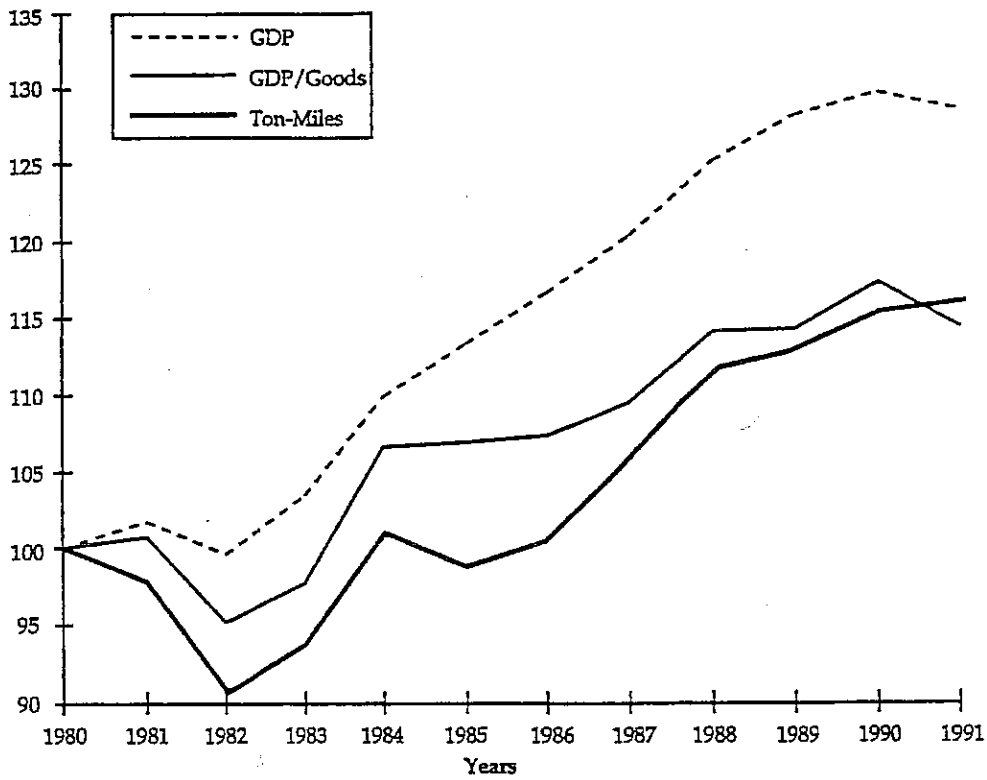


Figure 2.1: Relationship between freight demand, GDP and goods production.

Table 2.4: **Recent data on fatal crash rates and injury crash rates for large trucks and for passenger vehicles.**

	Fatal Crash Involvement Rates				Injury Crash Involvement Rates			
Year	Number of Trucks	Per 100 million VMT	Number of Passenger Vehicles	Per 100 million VMT	Number of Trucks	Per 100 million VMT	Number of Passenger Vehicles	Per 100 million VMT
1993	4,328	2.7	45,565	2.1	97,000	61	3,474,000	164
1994	4,644	2.7	46,626	2.1	95,000	56	3,697,000	170
1995	4,453	2.6	48,973	2.1	84,000	47	3,938,000	177
1996	4,755	2.6	48,973	2.1	94,000	51	3,988,000	175
1997	4,871	2.5	48,291	2.1	97,000	51	4,035,000	172

Source: Reproduced from *Large Truck Crash Profile: The 1997 National Picture.* Analysis Division, Office of Motor Carriers (OMC), FHWA. These data were reproduced from Fatal Analysis Reporting System (FARS), 1988-1997, General Estimates System (GES) 1988-97 and Highway Statistics, 1988-1997.

2.3 Review of Related Studies

This section reviews the literature on motor carrier/vehicle safety. For the purposes of the study, the following five categories of the literature have been considered:

1. Effect of regulatory policies and programs on truck accidents and safety violations (in Section 2.3.1).
2. Impact of traffic operations characteristics such as speed on upgrades, freeway ramp merging and weaving and intersection maneuvers and consequent impacts on CMV accident rates (in Section 2.3.2).
3. Effect of driver conditions (including hours-of-service, fatigue and impairment) on accident rates involving trucks (in Section 2.3.3).
4. Effects of environmental factors (in Section 2.3.4).
5. Effect of truck configuration (including handling and stability properties as well as weight) on truck accident rates (in Section 2.3.5).

2.3.1 Effect of regulatory policies and programs on truck accidents

One set of factors that could potentially affect truck accident rates is regulatory policies and programs. Such policies and programs are aimed at attacking the main causation factors of crashes: vehicle factors (e.g., inspections to assure trucks meet safety standards), driver factors (e.g., provide assurance that drivers are competent to operate the vehicle safely through a efficient licensing system) and highway/environmental factors (e.g., enforcement of traffic regulations). In this section, the regulatory environment of motor carrier operations is discussed.

The Federal Motor Carrier Administration (FMCSA) is responsible for the issuance, administration, and enforcement of the Federal Motor Carrier Safety Regulations (FMCSRs). The trucking industry has been economically deregulated since 1980. However, FMCSA has regulatory oversight over safety standards. Before 1999, the FMCSA was known as the Office of Motor Carriers (OMC) and was part of the Federal Highway Administration (FHWA). FMCSA is not an administration in U.S. Department of Transportation. The FMCSA's overall goal is to improve the safe transportation of passengers and goods on the U.S. highway network through a coordinated effort of Federal, State, and industry organizations to reduce fatalities, injuries, property damage and Hazardous Materials incidents.

The FMCSA's regulations have jurisdiction over approximately 450,000 interstate motor carriers operating in the U.S. About 70% of these motor carriers have fleet sizes of less then seven vehicles. According to the American Trucking Association (ATA), there are more than 9 million people employed in transporting cargo for interstate commerce. The FMCSA systems indicate that more

than 8 million people hold Commercial Vehicle Licenses (OMC, 1998). Motor carriers have the responsibility to comply with these regulations. Appendix B explains these regulations.

The Transportation Equity Act for the 21st Century (TEA-21), passed in June 1998, provides the funding that the FMCSA needs to implement new programs and strengthen old successful initiatives started during the previous transportation legislation (Intermodal Surface Transportation Efficiency Act or ISTEA).

The TEA-21 legislation provided a change in direction with respect to the previous legislation [Intermodal Surface Transportation Efficiency Act (ISTEA)] by:

1. providing more flexibility to the States to take action according to their needs
2. supporting information technology programs financially
3. giving the FMCSA and the States more authority to enforce safety standards.

The TEA-21 intends to strengthen the partnership between the FMCSA and the States through the participation in the Motor Carrier Safety Assistance Program (MCSAP). Over the life of TEA-21, the states will get grants rising from $79 million in 1998 to $110 million in 2003. Over six years MCSAP grants will total $579 million.

Under TEA-21, the States get more discretion in how they spend the funds they receive. Congress eliminated all the MCSAP earmarks stated previously in the ISTEA legislation. This reduces the number of required activities that the states must conduct, though the basic MCSAP grants will continue. These grants support programs such as roadside inspections, traffic enforcement, covert operations, roadside drug interdiction and compliance reviews.

The Act requires that by the year 2000, all States adopt "performance-based" programs. The objective is to redirect the annual state enforcement plans to focus on the results of the program (crash reduction). By removing the earmarks, Congress has given the states the flexibility to direct their resources to solve their own unique truck safety problems. This way they can focus on what is more urgent according to local needs, such as high-crash corridors, speeding, fatigue related crashes or even data/information related problems.

Congress also gave the states some regulatory relief. In the past, the paperwork required by the roadside Out-Of-Service (OOS)verification process was very long and time-consuming. First, reports were filed for roadside violations, and sent to the state agencies certifying that the problems were corrected. Then follow-up letters had to be mailed and tracked. This lengthy process was prescribed by statute. Congress eliminated this requirement by leaving it to the discretion of states to find the most effective way to deal with this non-compliance problem.

The TEA-21 provided $65 million dollars for the six-year period of the Act to fund information technology initiatives. This new funding category will support improvements of Federal and State

systems of carrier, vehicle, and driver safety records. In the long-term, advances and improvements in the area should allow the identification of high-risk carriers. A very important aspect of this funding category is the flexibility in which its funds can be used for grants, cooperative agreements or contracts.

The ISTEA legislation initiated the Performance and Registration Information System Management program (PRISM) program which links federal safety data with state vehicle registration information to identify at-risk carriers with this funding. Part of the program includes the application of progressive sanctions including the loss of vehicle registration privileges if the carriers are unsafe. The PRISM pilot program that started with five States can now be extended to become a nationwide system.

The TEA-21 also expands the Federal authority for shutting down carriers that fail to meet safety fitness requirements. In the past this authority was limited to hazardous and passenger carriers. The TEA-21 extends it to all carriers (according to FMCSA estimates, approximately 8,000 carriers rated unsatisfactory continued to operate). The carriers have 60 days to correct their problems and another 60-day grace period is given if there is a genuine effort to make improvements. In the area of civil penalties the carriers are to be more conscious about safety issues. Now fines can be up to $10,000 per safety violation. In the past there had to be a serious pattern of violations or gross negligence in order to impose fines.

Another important change is the definition of Commercial Motor Vehicle (CMV). In the 1984 Safety Act, the definition was based on the manufacturer's gross weight rating. The definition has now been changed to include the gross vehicle weight (operating weight). Other safety related matters addressed in this legislation are the issues of shippers that apply pressure on carriers to meet delivery schedules, increased regulatory flexibility given to the FMCSA for safety waivers and exemptions.

Carrier-Level Analysis of Safety Performance

Carrier level analysis of crash rates have been conducted by several researchers. The major interest in this study is differences in the crash rates and inspection violation rates of interstate and intrastate carriers and interstate and intrastate CMVs. An interstate carrier may own and operate CMVs that are licensed to operate in multiple states (interstate CMV) as well as CMVs that are licensed to operate only within one state (intrastate CMV). On the other hand, intrastate carriers typically own and operate CMVs that operate within one state. Hence, all intrastate CMVs do not belong to intrastate carriers alone.

Table 2.5 shows fatal crash involvement numbers for trucks belonging to interstate and intrastate carriers as well as to governmental agencies and rental trucks for 1992. The data are from the Trucks Involved in Fatal Accident (TIFA) database, which is produced by the University of Michigan Transportation Research Institute. About 63% of trucks involved in fatal crashes belong to interstate carriers and about 28% to intrastate carriers. It is important to recognize that the table does not show fatal crash *rates*. Because of this reason, the safety performance of the two types of carriers

Table 2.5: **Fatal crash involvements by trucks owned by type of company.**

Company Type	Frequency	Percent
Interstate	2,629	62.8
Private	792	18.9
For-hire		
Authorized	1,766	42.2
Exempt	71	1.7
Intrastate	1,161	27.7
Private	808	19.3
For-hire	353	8.4
Government	102	2.4
Daily rental	32	0.8
Unknown	261	6.2

Source: Trucks Involved in Fatal Accidents (TIFA), 1992, University of Michigan Transportation Research Institute.

cannot be compared.

The data for the interstate and intrastate categories are further divided into private and for-hire categories. Private carriers are those which own and operate motor carrier vehicles to transport the company's own goods while for-hire carriers are those which provide transportation services to other companies for a fee. Based on these classifications, it appears that trucks belonging to interstate for-hire authorized carriers have the highest percent fatal crash involvements.

Evaluation of Federal Motor Carrier Safety Programs

An analysis of the U.S. Motor Carrier Safety Programs (Moses and Savage, 1997) investigated the costs and benefits of two government safety compliance programs aimed at the interstate trucking industry in the U.S. The first program studied involves "Safety Review" (SR) visits to the trucking firms. Managers are questioned about safety-related procedures and policies such as those governing maintenance, driver training and hiring. A point-rating system is used to determine whether the carrier receives a satisfactory safety rating. The second program is a system of roadside inspections called the Motor Carrier Safety Assistance Program (MCSAP). The program was authorized under the 1982 Surface Transportation Assistance Act (STAA) which provided federal funds to states to cover 80% of the cost of these safety inspections. In 1991, 1.1 million interstate vehicles were stopped for 30-minute inspections at weight stations (Moses and Savage, 1997).

The technique used in that study can provide safety regulators with an empirical approach to identify the most dangerous firms. As a result it would be easy to target enforcement and educational processes aimed at closing loopholes in the motor carrier system. The authors used a negative-

binomial regression procedure on a data set of 20,000 firms. The definition of poor performance in roadside inspection is based on both the rate of inspections per fleet mile and the average number of violations found during an inspection. The study suggests that both of the government's programs have helped to identify the most dangerous firms. The results are clear: the 2.5% of firms that do poorly in both programs have an average accident rate twice that of the mean for all other firms.

Uniform inspection procedures apply throughout the United States and Canada. Inspectors conduct a comprehensive mechanical examination of vehicles, and check that drivers have correct licenses, have adhered to hours-of-service rules, and are not under the influence of drugs or alcohol. The program has enforcement authority under which vehicles and/or drivers failing to comply are placed Out-Of-Service on the spot until the problem is resolved. Moses and Savage attempted to calculate the financial benefits and costs of the two programs.

Under the directive of the House of Representatives, the U.S. General Accounting Office of the Federal Government examined the efficiency and effectiveness of the Motor Carriers' commercial motor vehicle safety programs. As a result of the Surface Transportation Assistance Act of 1982 (STAA), the Motor Carrier Safety Assistance Program (MCSAP) was established in 1983. The program was to provide grants to states. The basic idea was to support commercial motor vehicle safety programs aimed at (1) large trucks that have a gross vehicle weight rating of at least 10,000 pounds, (2) vehicles used to transport more than passengers, and (3) vehicles used to transport hazardous materials. Under MCSAP, the federal government would fund up to 80% of the costs of each state's motor carrier safety program (GAO 1997).

The ISTEA made headways in the use of new technologies to apply them to information systems capacity enhancement. The ISTEA required that by January 1994, each of the 48 contiguous states participate in SAFETYNET, the FMCSA's automated database system used to monitor the safety performance of commercial motor carriers. The act also directed FMCSA to provide grants for states to develop a Commercial Vehicle Information System that would link FMCSA's motor carrier safety information with states' motor vehicle registration systems. The Commercial Vehicle Information System project led to the development of FMCSA's Safety Status Measurement System (SafeStat) program.

According to this study from 1983 through 1995, the rate of fatal accidents involving large trucks dropped by 42%–from 4.3 to 2.5 fatal accidents per 100 million vehicle miles traveled. The lower fatal accident rate reflects a (1) 57% growth in total vehicle miles driven by large trucks and (2) 9% drop in the number of large trucks involved in fatal accidents (General Accounting Office, GAO/RCED-98-8, 1997). It is important to point out that almost all of this decline occurred during MCSAP's first 10 years. After 1992 the fatal accident rate has been relatively stable.

2.3.2 Effect of Traffic Operation Characteristics

While the carrier safety practices and regulatory environment are important for preventing crashes, driving conditions play a major role in the propensity of vehicles to be involved in crashes. This

section examines the effect of traffic operation characteristics such as speed on upgrades, freeway ramp, merging and weaving and intersection maneuvers and consequent impacts on CMV accident rates on truck safety. A TRB (1987) report reviewed existing research and commissioned new research to quantify the relationship between improvements in highway design and accident reduction. While the research reviewed here is not directly related to trucks, it is important that the findings are highlighted here because they have implications for truck safety as well.

At least six highway design features identified in the TRB study proved to have a significant bearing on the accident rates of commercial vehicles traveling on access roads:

1. Lane and shoulder width and type: Adequate lane width is important to provide sufficient lateral separation between vehicles to avert sideswipe and head-on collisions of vehicles on two-lane roads. Ample shoulder width is also important to increase the opportunity for safe recovery when vehicles run off the road. Research findings indicate that increasing lane and shoulder width can reduce the risk of certain types of accidents. However, pavement widening, per foot of added width, has a greater accident risk reduction payoff than does shoulder widening, and stabilized shoulders reduce accidents more than unstabilized shoulders (TRB 1987, 81-83). For instance, widening lanes from 9 to 12 ft without any shoulder improvements is projected reduce accidents by as much as 32% for all types of vehicles. Adding 3 ft of unstabilized shoulder improvements is projected to reduce accidents by 19%, and adding 3 ft stabilized shoulder increases the projected reduction to 22%(TRB 1987, 81-83). A very interesting point is that the widening benefits are not linear. The largest benefit is achieved by the first foot of lane widening (Zeeger et al. 1987, 153).

2. Bridge width: Again as in the previous case, the width of a bridge has a direct relationship with accident rates. Increasing the width of the bridge in relationship to the approach lanes can reduce accidents by an estimated 40%(TRB 1987, 87). And as in the previous case, the greatest improvement in safety, about 30% is captured in the first foot of widening.

3. Roadside and sideslopes: In the case of bridge width, accident risk is increased when bridge approaches are on a downward grade, which can increase vehicle speed, and are sharply curved, which is common with older structures.

4. Pavement and edge drops: TRB research points to the fact that correcting pavement edge drops may have important safety ramifications. The longer the truck the more susceptible to edge drops on the side of horizontal curves because of inward off tracking of the rear wheels of the truck (TRB 1987, 97).

5. Horizontal curves: It is no surprise that accidents are more likely to occur on curved than straight segment of roads. Research suggests a linear relationship between the degree of curvature and relative accident rates such that each degree of decrease in curvature results, on average, in three fewer accidents for every 100 million vehicles passing through the curve (TRB 1987, 91).

6. Intersections: A substantial number of accidents occur at intersections, about 55% of urban accidents and 32 percent of rural accidents. Twenty-eight percent of the fatal accidents that take

place on urban highways and 15% of those that take place on rural highways are intersection-related (Accident Facts 1987, 50).

2.3.3 Effect of Driver Conditions

In this section, studies on the effect of the condition of the driver, including hours-of-service, fatigue and impairment, on accident rates of trucks are reviewed. The Commercial Motor Vehicle Safety Act (CMVSA) of 1986 established uniform federal standards for testing and licensing to ensure the "fitness" of persons who operate commercial motor vehicles.

Paul, Lyles and Narupiti (1998) tried to determine if the result of standardized testing could be directly linked to safer commercial vehicle operation in Michigan. They studied the relationship between Commercial Driver License (CDL) test performance, driver demographics, driver attitudes, driver knowledge, and driver safety-related history. These relationships were used to examine questions such as: are alternate forms of the CDL test equivalent; are there the problems with testing bias; is the CDL test"good" at differentiating between drivers with safe or unsafe driving habits; can CDL test scores be related to driver safety; and, does the CDL test penalize drivers who have good driving records, but poor verbal skills? The analysis resulted in the identification of several negative aspects of the CDL test. First, the alternate forms of the CDL are not equivalent. Second, educational, racial, and gender biases were identified in the CDL test structure. Finally, the CDL test structure may penalize drivers with "safe" driving records but poor verbal skills. Several positive aspects were also identified. First, the CDL study manual aids drivers in meeting the minimum knowledge requirements for the operation of commercial vehicles. Most importantly, the CDL test is an effective tool for identifying safe drivers.

The Federal Highway Administration requires all motor carriers employing drivers holding CDLs to have a drug and alcohol testing program. Carriers must randomly test a fixed percentage of their CDL drivers each year for both alcohol (for which 10% of all drivers must be tested annually) and for a specific set of controlled substances (for which 50% of all drivers must be tested annually). In the case of alcohol, a driver is considered to have tested positive if the blood alcohol content is 0.04 grams per deciliter or higher. For controlled substances, drivers are tested for marijuana, cocaine, opiates, amphetamines and PCP. The cutoff levels for identifying the use of these drugs are based on guidelines set by the department of Health and Human services. In addition to random testing, FHWA's drug and alcohol testing regulations require motor carriers to perform following types of non-random testing: pre-employment testing (if the driver has not recently been in a drug and alcohol testing program); post-accident testing (if the crash involved a fatality, or if the crash involved both towaway or hospital-related injury and the truck driver received a citation); and testing of any driver who is suspected by a supervisor of using drugs or alcohol while at work.

2.3.4 Effect of Environmental Factors

Environmental factors are considered to have an impact in on the safety of Commercial Motor Vehicles. However, it was difficult to find a lot of material of this effect on truck crashes, the most common factors studied are those such as rain, snow, fog and high-winds. Inclement weather, such as rain, sleet, snow and ice creates road conditions that challenge the stability and control of vehicles during turning and braking maneuvers.

Visibility is a function of weather as well as time of the day. Dawn, dusk and night place increased operating demands on the driver to safety control the vehicle. Crash vehicles profile illustrate that approximately 35% of fatal crash and about 26 percent of non-fatal crashes occur in visibility conditions other than normal daylight (U.S.DOT, Truck Size and Weight Study, 1997).

2.3.5 Effect of Truck Configuration

Several studies have focused on the differences in safety performance by vehicle configuration. In a five-year study of national fatal accident data (1980-1984) by Campbell *et al.* (1988), it was found that when fatal accident involvement rates were analyzed by vehicle configuration, twin trailer trucks were slightly underinvolved at 0.90 and tractor-semitrailers were slightly overinvolved at 1.06 in comparison with a normalized rate of 1.0 for all truck configurations. It is important to point, however, that these results may not reflect differences in truck travel by road class, time of the day, and area as well as specific vehicle configuration. When the analysis was adjusted to control for these factors and isolate the effect of configuration, twin trailer trucks showed a 10% higher fatal accident involvement rate than did tractor-semitrailers (Campbell *et al.* 1988, 40).

O'Day, J., and L.P. Kostyniuk (1985) explored the direct safety effects of increasing the number of large trucks in urban areas. A simple theoretical model of consequences of mixing trucks with cars is presented. The model, supported by recent detailed data from national in-depth accident investigation programs, indicates that the physical difference of mass between the two types of vehicle inevitably leads to a larger number of fatalities unless there is a concomitant reduction in the probability of such collisions. A comparison of urban and rural truck accident experience shows that the most severe urban accidents occur on urban interstate roads. Therefore, traffic engineers will be challenged by the problems associated with an increased truck population and will need to continue developing ways of reducing the chances of contact between the two types of vehicles in traffic flow.

2.4 Review of Commercial Motor Carrier/Vehicle Safety and Exposure Databases

An essential component of heavy truck safety measurement and evaluation is complete and accurate databases that contain relevant accident and exposure statistics (Seiff, 1990). In this section, we

summarize a review of the databases that are available to analyze safety performance of motor carriers and commercial vehicles. The summary is presented in tabular form. Detailed descriptions of the databases are given in Appendix C of this report.

In most safety studies, two categories of data are relevant: data on safety and data on exposures. In this study, the interest is focused on two categories of databases: **Category 1:** those on motor carrier safety aspects, including data on crashes, inspection violations and **Category 2:** those that allow us to estimate exposure measures of the categories of commercial motor carriers under analysis.

The summary given here is presented in the form of two sets of tables that follows the above classification of databases. Tables 2.6 and 2.7 summarize our review of Category 1 databases. The table presents the name of the database, the entity that maintains the database and a brief description of database. Table 2.8 summarizes our review of Category 2 databases. The database name, the entity that maintains the database and a brief description of exposure databases are presented in that table.

Table 2.6: **Databases available for the study**

S. No	**State Motor Carrier Safety Databases**		
	Database Title	**Source**	**Brief Description**
1	IDOT Carsh Files	IDOT	The IDOT Crash files contain information on all the crashes involving vehicles that occurred within the state of Illinois. Crashes that involved trucks are supplemented with additional data on carriers and other respective details.
2	ISP Inspection Files	IL State Police	The ISP Inspection files contain an extensive record of the various levels of Inspection carried out on different types of Commercial Motor vehicles. The data set contains a complete record of different types of violations. The inspection files contain information on interstate as well as intrastate CMV's that are inspected.
	National Safety Databases		
1	FMCSA Crash File	FMCSA	The FMCSA crash file contains data on a subset of police crash reports involving drivers and vehicles of motor carriers operating in the United States. Each report contains about 80 data elements pertaining to motor carrier, driver, vehicles, fatalities, injuries and circumstances of a crash.
2	FMCSA Inspection File	FMCSA	The FMCSA Inspection file contains data from the roadside inspection reports involving drivers and vehicles of motor carriers operating in the United States. Each report contains about 80 data elements pertaining to the motor carrier, driver, vehicles and circumstances of an inspection.
3	FMCSA carrier File	FMCSA	This gives a detailed description of the status of the carrier, type of operation in which the entity is engaged, fleet characteristics and safety-related information.

Table 2.7: **Databases available for the study**

	Other Available Databases		
S. No	**Database Title**	**Source**	**Brief Description**
1	Fatal Accident Reporting System (FARS)	National Highway Transportation Safety Administration (NHTSA)	This database is on fatal crashes only and is regarded to be the most reliable source of data on this issue. The FARS database consists of police reports of the crashes that result in at least one fatality within 30 days of the crash. It contains information on the vehicle, roadway, state, accident, circumstances, driver and occupants.
2	General Estimates System (GES)	National Highway Transportation Safety Administration (NHTSA)	GES obtains data from a nationally representative probability sample selected from the estimated 6.5 million police reported crashes that occur annually. GES concentrates on those crashes of the greatest concern to the highway safety community and general public.
3	Trucks Involved In Fatal Accidents (TIFA)	University of Michigan Transportation Research Institute (UMTRI)	TIFA combines data from FARS with police accident reports and telephone interviews conducted by UMTRI research staff. The TIFA contains data on most FARS variables and has information on all medium and heavy trucks involved in fatal accidents.

Table 2.8: **Databases available for the study**

	Exposure Databases		
S. No	**Database Title**	**Source**	**Years Available**
1	Highway Performance Monitoring System (HPMS)	Federal Highway Administration (FHWA)	This is a nationwide inventory system that includes mileage on all public roads in the US. The primary purpose of the HPMS is to serve the data and Information needs of the FHWA and Congress.
2	Vehicle Inventory and Use Survey (VIUS)	Bureau of Census	The VIUS provides detailed data (at the level of trucks) on the physical and operational characteristics of a random sample of the truck population in the US. VIUS can be used to provide estimates of AVMT on moving different classes of goods and commodities, type of operation, type of service and other indices that could provide a comprehensive picture of truck travel.
3	Commodity Flow Survey (CFS)	Bureau of Transportation Statitics (BTS) and the Bureau of Census	This data could be potentially used to estimate truck exposures. It gives information on origins and destinations of shipments, size of shipments, mode of transportation and other related information.
4	FMCSA Carrier Census File	(FMCSA)	This file provides mileage data at the firm-level. This data may be useful as an exposure measure only if the analysis of safety is at the level of the carrier.
5	Motor Fuel Tax Bureau Data	State Motor Fuel Tax Bereau	This data is on the miles driven by trucks belonging to carriers domiciled in a particular state. This is a legal requirement, given tax reciprocity arrangements among states.

Chapter 3

Data Linking

3.1 Safety and Exposure Measures: Need for Data Linking

The structure of a data linking problem is specific to the research questions that need to be answered. In this study, there are four major research questions with data linking implications:

1. Are crash rates different for interstate and intrastate CMVs and carriers?

2. Are inspection violation rates different for interstate and intrastate CMVs and carriers?

3. Of all the CMVs that incurred inspection violations in Illinois, how many were subsequently involved in crashes? If the probability of a crash is different for interstate and intrastate CMVs?

4. What is the level of exposure or Vehicle Miles Traveled (VMT) of interstate and intrastate CMVs?

Answering these research questions require the linkage of different types of databases. As indicated in Chapter 2, the current study focuses on two categories of databases: **Category 1:** those on motor carrier safety aspects, including data on crashes, inspection violations and **Category 2:** those which allow the estimation of exposures of each category of commercial motor carriers under analysis. In this chapter, the linkage of different databases, to facilitate investigation of the research objectives of the study, are discussed.

Safety databases (Category 1) used are briefly summarized in Section 3.2. The rationale and the approach used to link different safety databases are given in Section 3.3; this is a discussion of the linkage procedures used to answer Questions 1 through 3 above. The exposure databases are

summarized in Section 3.4. Discussions pertaining to linking different exposure-related databases provides the information base for answering Question 4 above to be answered.

The data linking problem involves the following steps:

1. Develop objectives for linking databases
2. Operationalize the objectives by developing specific logic
3. Develop the code to accomplish the linking
4. Test and validate the linking process
5. Develop data dictionaries and summary statistics of the databases.

This chapter reports on steps 1 through 3 above for both safety and exposure databases. Steps 4 and 5 for safety data linking is given in Appendix D. Steps 4 and 5 for exposure data linking are included in Chapter 4, titled *Research Methodology*.

3.2 Safety Databases Used in the Study

This study utilizes safety-related data from several sources: Illinois Department of Transportation (IDOT), Illinois State Police (ISP), Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Transportation Safety Administration (NHTSA). These databases are described in detail in Appendix C. Database names, sources and years considered in this study are given in Table 3.1 below.

Table 3.1: **Safety databases analyzed**

I.	Safety Databases		
S. No	Database Title	Source	Years Analyzed
	Illinois State Databases		
1	Crash File	IDOT	1994 - 1996
2	Inspection Files	Illinois State Police	1993 - 1998
	National Databases		
1	Census File	FMCSA	Updated till 1998
2	Crash File	FMCSA	1993 - Oct. 1998
3	Inspection Files	FMCSA	1993 - Oct. 1998
4	Fatal Analysis Reporting System	NHTSA	1993 - 1998

3.3 Safety Data Linking Process

In this section, the approach taken to link the different safety databases is described. There are two major purposes for safety data linking:

Problem I: To develop the logic and the code to:

1. Develop definitions of interstate and intrastate carriers and interstate and intrastate CMVs
2. Reliably identify a CMV as interstate or intrastate
3. Reliably identify the carrier as interstate or intrastate.

Problem II: To develop the logic and the code to:

1. Identify the crash history of vehicles that were inspected in the roadside in Illinois
2. Identify the carrier safety history of trucks that incurred roadside inspection violations.

3.3.1 Problem I: Identification of Vehicles

Databases were linked at both the vehicle level and carrier level. These are the two elements under analysis in this study. The question here is: what is an interstate or an intrastate carrier from the perspective of Illinois and what is an interstate or intrastate CMV from the same perspective? This section explores the issues further and provides the necessary definitions. The objective is to correctly identify vehicles in the inspection files and crash files as interstate or intrastate vehicle.

Two definitions were developed for each vehicle: CMV1 and CMV2. Both definitions employ information on the carrier of the vehicle, the license number of the vehicle and license state. The primary information required to classify the vehicle are the license state and the license numbers. Whether the carrier is interstate or not is used as a secondary tier of information. This logic was employed under the premise that interstate carriers may own and operate intrastate vehicles. On the other hand, a vehicle owned by an intrastate carrier may travel out of state with special licenses/permits.

To identify whether a CMV has the authority to engage in interstate commerce or intrastate commerce, a technique, taking advantage of commercial vehicle license plate numbering tradition, was developed. Essentially, large interstate trucks have a special licensing convention. CMV2 defines a truck to be interstate or intrastate from the perspective of the State of Illinois. Any Illinois truck that can travel out of Illinois (which can be known from its special license) is designated as interstate, even if it is owned by an intrastate carrier. Similarly, any truck registered outside Illinois, but has traveled to Illinois (since it is in the Illinois ISP Files or Crash Files) is designated as interstate, even if it belongs to a non-Illinois intrastate carrier.

CMV1, on the other hand, breaks down the interstate/intrastate categorization further, by designating trucks into interstate and intrastate by state of registration as well as by the size of the vehicle. CMV1 has a category called "Other" which means a vehicle with a known license state, but the jurisdiction of operation of which (whether it is allowed to engage in interstate commerce or not) is not known.

Vehicle designation therefore followed a two-tier system:

1. Identify special designation in license plate number.
2. Combine that identification with carrier information.

Specific details of the process are given in Section D.1 of Appendix D. Definitions of CMV1 and CMV2 are summarized in Table 3.2.

Table 3.2: **Classification of commercial motor vehicles into two categories, CMV1 and CMV2.**

Carrier	License Number	License State	CMV1	CMV2*
Interstate	Special	IL	IL-Interstate	Interstate
Interstate	Special	Not IL	NL-IL Interstate	Interstate
Interstate	Not Special	IL	IL-Other	Interstate
Interstate	Not Special	Not IL	NL-Other	Interstate
Intrastate	Special	IL	IL-Interstate	Interstate
Intrastate	Special	Not IL	NL-Interstate	Interstate
Intrastate	Not Special	IL	IL-Intrastate	Intrastate
Intrastate	Not Special	Not IL	NL-Intrastate	Interstate

* Defined from the perspective of operations in Illinois.

Carriers or firms also has to be defined as interstate or intrastate depending on the perspective of the study. For this purpose, we created two variables: CARRIER1 and CARRIER2. In order to create these variables, we need information on whether the carrier is interstate or intrastate and the state of domicile of the business. The logic employed for this classification is given in Table 3.3.

As with the case of vehicles, carriers are defined as interstate or intrastate from the perspective of operations within Illinois by means of the variable CARRIER2. Since the bulk of the analysis in this project is to compare interstate and intrastate carriers and CMVs, any observation in any database that cannot be identified as belonging to either interstate or intrastate carriers or CMVs or cannot be linked to another database where its classification identity is known, is essentially useless for our purposes.

Table 3.3: **Classification of commercial carriers into two categories, CARRIER1 and CARRIER2.**

Carrier	Domicile State	CARRIER1	CARRIER2*
Interstate	IL	IL-Interstate	Interstate
Interstate	Not-IL	NL-Interstate	Interstate
Intrastate	IL	IL-Intrastate	Intrastate
Intrastate	Not-IL	NL-Intrastate	Interstate

* Defined from the perspective of operations in Illinois.

Vehicle Identification in Databases

The "universe" of commercial vehicle crashes in Illinois is the Illinois Department of Transportation's (IDOT) Crash Files. The study is interested in obtaining the crash rates of CMVs that are registered for conducting interstate and intrastate commerce. Also, the study is interested in comparing crash rates (within Illinois) of interstate and intrastate carriers.

Whereas obtaining a count of crashes [the numerator of the crash rate] should be a relatively simple issue, it turned out to be quite challenging. This was due to the fact that various identification variables that are needed to categorize the CMVs were not available directly from the IDOT Crash Files. The data on license state and numbers and additional data such as US DOT, state DOT or other carrier identifiers are entered only for the subset of CMV crashes that are sent to the FMCSA Crash File[1].

Hence, whether a CMV in the IDOT Crash Files was interstate or intrastate could be determined only by linking the IDOT Crash Files to the other databases that were available. The only variable that allowed this linking was the Vehicle Identification Number (VIN), a variable that was available in the IDOT Crash Files, the FMCSA Crash and Inspection Files and the ISP Inspection Files. The FMCSA Crash and Inspection Files and the ISP Inspection Files had data on license numbers, license states and VINs. Once the IDOT crash files are successfully linked to the FMCSA Crash and Inspection Files and the ISP Inspection Files on the basis of VIN's, it is possible to identify which CMV category in the IDOT Crash Files to which it belongs.

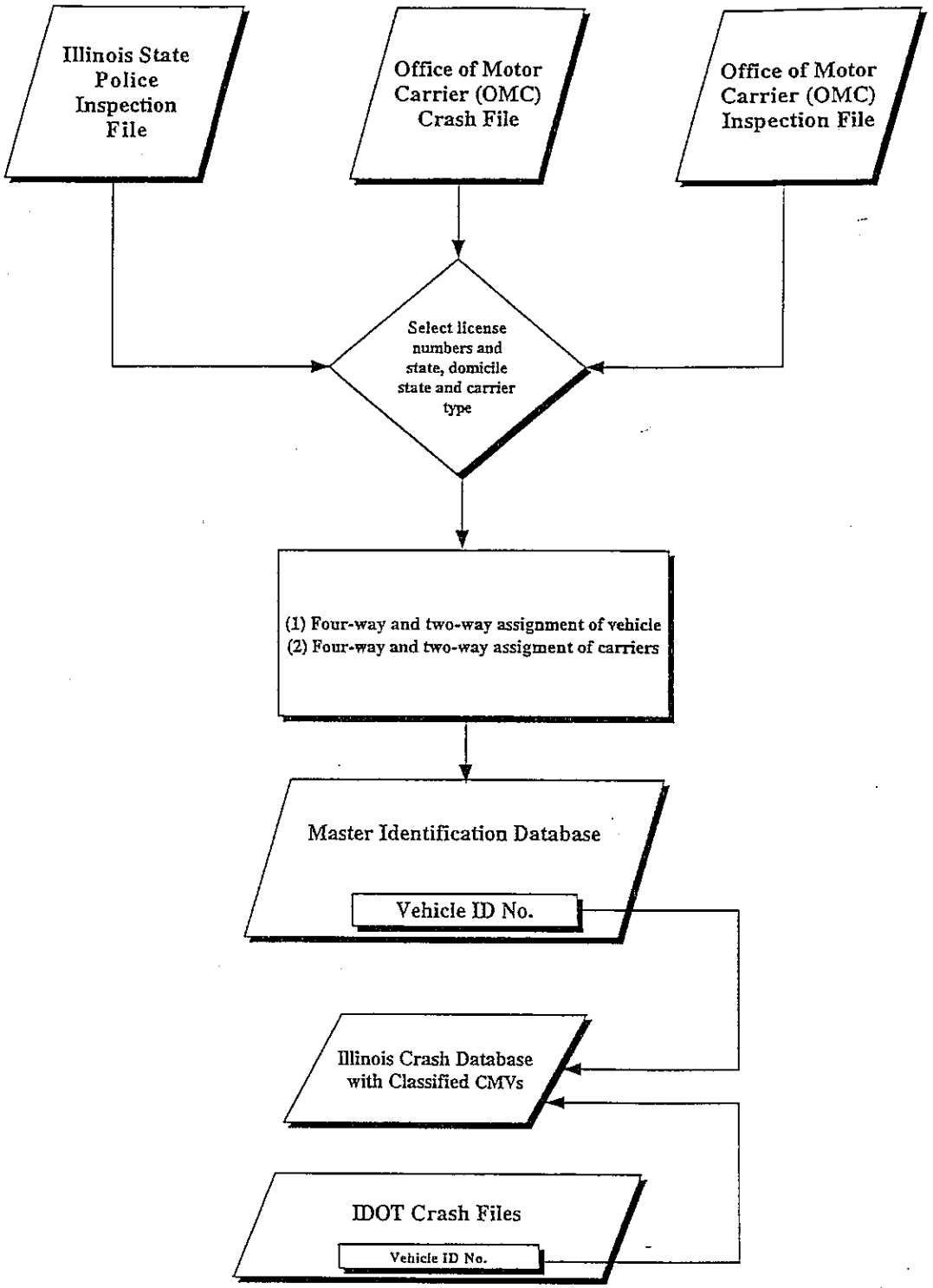


Figure 3.1: Process of creating Master Identification Database (MID).

3.3.2 Vehicle-level crash rate categorization

This section describes the process by means of which crash rates by the interstate/intrastate categorization (at the vehicle level and at the carrier level) was obtained.

The starting point in estimating crash rates for interstate and intrastate CMVs was to create a master list of (i) license numbers, (ii) license states, (iii) VIN's, (iv) US DOT numbers, (v) State DOT numbers and (vi) Commerce Commission numbers of all CMVs (registered in any state in the US) from the FMCSA Crash and Inspection Files and the ISP Files. Data for all years for which the information was available and was used in the process. This list is the Master Identification Database (MID). The process by which the MID was created is given in Figure 3.1. The MID, with data from the three sources, FMCSA Crash Files, FMCSA Inspection Files and the ISP Inspection Files have complete identifiers on about 1.5 million CMVs.

The MID, therefore, is a list, containing the following types of identifiers for each vehicle:

1. License state
2. License number
3. VIN
4. Carrier IDs (including USDOT Numbers, State DOT Numbers, ICC Numbers and other such identifiers)
5. Safey variables (if any)
6. CMV1, CMV2, CARRIER1 and CARRIER2

Details on the MID and the contribution of the ISP Files, the FMCSA Inspection and Crash Files to the development of the MID are given in Section D.2 of Appendix D of this report.

For the years 1994, 1995 and 1996, out of the total number of commercial vehicles involved in crashes (as documented in the IDOT Crash Files), only about 46% could be classified as interstate or intrastate CMVs. Vehicles could not be classified perhaps due to the following reasons:

1. These vehicles were never inspected or never had crashes and are therefore not in the MID.
2. These vehicles were never inspected or had crashes within the time period on the basis of which the MID data was created.
3. They were inspected or had a crash outside Illinois, but the state where they incurred the crash or was inspected did not upload the data to the federal databases.

[1]These issues were explained to the project team by Lorie Midden of the Traffic Statistics Unit of the Division of Traffic Safety, Illinois Department of Transportation.

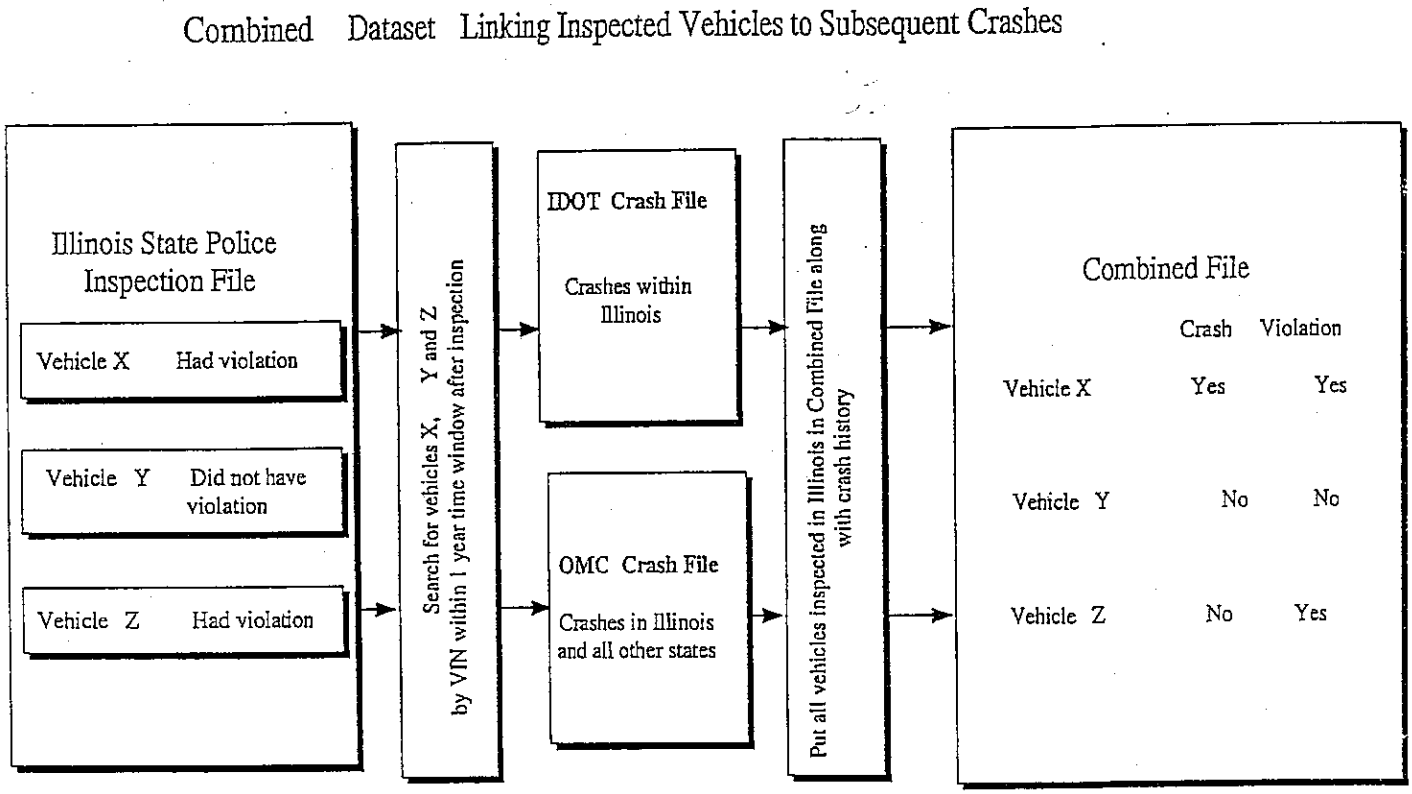


Figure 3.2: Process of creating the Combined Crash-Inspection File.

3.3.3 Problem II: Data Linking to Obtain Crashes of Inspected Vehicles

Problem II deals with the issue of developing the logic and the code to identify the crash history of vehicles that were inspected in the roadside in Illinois. This problem deals with the third question which this study addresses (given in Section 3.1 above), that is, of all the CMVs that were inspected in Illinois, how many were subsequently involved in crashes? In order to answer this, motor carrier inspection files and crash files had to be linked in a manner described in this section. This sort of linking would allow us to understand the relationships between the violations incurred in a safety inspection and crashes. This linked database (which is called the Combined file in this report) would also be used to develop the combined safety index referred to in Section 1.3 above.

In order to find out how many vehicles inspected in Illinois were subsequently involved in a crash, there needs to be a link between the ISP Inspection Files with the crash files considered in this study. A vehicle inspected in Illinois could be involved in a crash in another state and therefore it is necessary to look at FMCSA Crash File. Further, it is necessary to append to the linked file, known characteristics of the carrier to which the vehicle belongs. A computer program was written for the purpose of linking the ISP Inspection Files, the MCMIS Census File, the IDOT Crash Files and the FMCSA Crash Files.

The linking of databases to create the Combined File was carried out by the process shown in Figure 3.2. As the figure shows, starting from the ISP Inspection File, the program looks for crash records of each inspected vehicle in both the FMCSA Crash File and the IDOT Crash Files. This search is conducted on the basics of VIN's. This is done for a one-year time window after the inspection event. If one or more crash record for an inspected vehicle is found, then that information is added to the final Combined File. If no record is found, then the Combined File only retains the vehicle's inspection history.

Details on the Combined File are given in Section D.3 of Appendix D. The Combined File contains information on the vehicle's inspection history and its crash history. In addition, it includes identifiers such as license number and license state and the USDOT and other identifiers of the carriers to which the vehicle belongs. The combined file also includes the data on the variables created for the purpose of this study, CMV1 and CMV2 as well as CARRIER1 and CARRIER2.

3.4 Exposure Database Linking

This section describes the methods behind linking different exposure-related databases. The specific method used to estimate VMT is described in Chapter 4. The results of the estimation process is presented in Chapter 5.

This linkage activity provides the information base for Question 4 in Section 3.1 above. The correct estimation of appropriate exposure measures is critical in crash and safety history studies. This fact applies to the current study as well. Since the study compares the crash rates and inspection

violation rates of two groups of vehicles (interstate and Illinois intrastate CMVs), care must be taken not to overestimate or underestimate the exposure of one group relative to the other because that could have a strong impact on the result of the comparisons.

In order to estimate miles traveled by interstate and intrastate CMVs, the databases given in Table 3.4 were used. The databases include the Truck Inventory and Use Survey (TIUS) of the Bureau of Census (1992), truck registration data obtained from the Illinois Secretary of State's Office and the IDOT estimates of Annual Vehicle Miles Traveled.

Table 3.4: **Exposure databases analyzed in the current study**

II.	Exposure Databases		
S. No	Database Title	Source	Years Analyzed
1	Truck registration data	Office of Secretary of State, IL	1993-1998
2	AVMT data	IDOT	1993-1997
3	Truck Inventory and Use Survey (TIUS)	Bureau of Census	1992

All states are required to develop estimates of Vehicle Miles Traveled (by type of facility and by 13 different vehicle classes). These are the IDOT Annual Vehicle Miles Traveled (AVMT) referred to in Table 3.4. IDOT estimates VMT of several different categories of CMVs using Highway Performance Monitoring System (HPMS) procedures. Our objective is to ascertain the share or "split" of these total CMV miles that are driven by interstate and intrastate CMVs. This splitting process required linking the data on truck registrations and estimates of miles driven obtained from the TIUS.

The data source used to 'split' mileage incurred within Illinois into the different categories described in Section 4.2.1 is the Truck Inventory and Use Survey (TIUS). The TIUS is a part of the Census of Transportation, conducted by the U.S. Census Bureau. It provides data on the physical and operational characteristics of a randomly selected sample of private and commercial trucks registered (or licensed) in each state. Trucks owned by federal, state and local governments, ambulances, buses and motor homes were excluded from the survey. The survey was most recently conducted in 1987, 1992 and 1997. The 1997 data for Illinois are expected to be published in April or May of 1999. For the current study, we used the data from 1992.

To the best of the knowledge of the authors of this report, this is the only readily-available source that gives data on the share of a truck's total mileage in the survey year within the state to which it belongs and elsewhere. Although not available in a straightforward way, this was also the only readily-available source to estimate mileage by interstate and intrastate trucks.

Figure 3.3 gives the data linking activity that allowed the estimation of miles driven by trucks within Illinois. The detailed methods used are presented in Chapter 4.

The TIUS gives annual miles driven by each vehicle and also identifies whether a truck has the

authority to operate in interstate or intrastate jurisdictions. As shown in Figure 3.3, using this data, an average per-vehicle estimate of miles driven (by interstate and intrastate CMVs) was developed. This data was linked to the number of vehicles registered in Illinois using vehicle registration data, so that a factored estimate was available on the miles driven by trucks registered in Illinois. Using methods described in Chapter 4 and the IDOT truck AVMT data, the final output of this data linking process is an estimate of the number of miles driven by intrastate trucks and all interstate (Illinois-based and non-Illinois based) in Illinois.

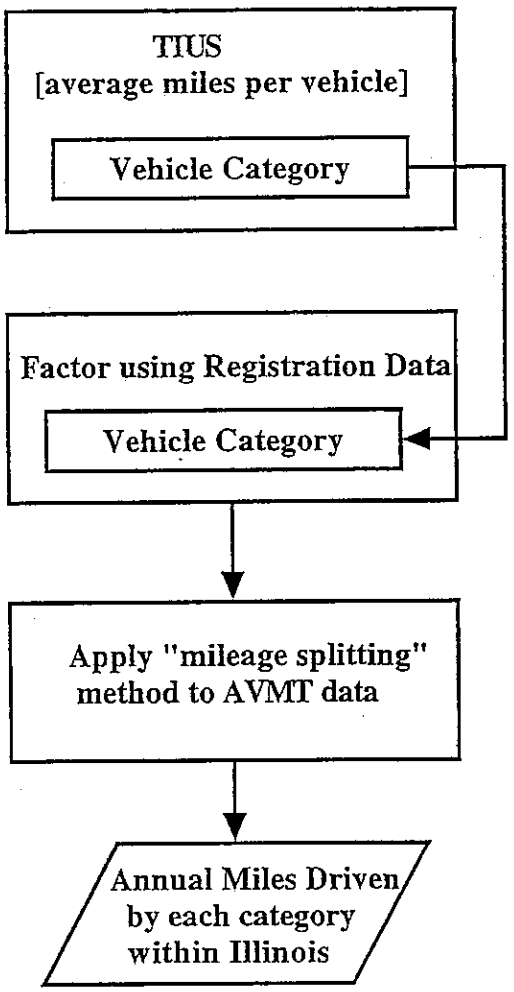


Figure 3.3: Data linkage for estimation of interstate and intrastate CMV mileage within Illinois.

Chapter 4

Research Methodology

4.1 Objectives of the Study

As described in Chapter 1, the study has the following research objectives:

1. To provide a descriptive summary of Illinois intrastate and interstate truck safety violations and crash patterns in Illinois.
2. To determine the extent of difference, if any, between the safety records of interstate CMVs and Illinois intrastate CMVs.
3. To evaluate relevant crash, commercial motor vehicle inspection and exposure databases in terms of their usefulness in analyzing the differences.
4. To create linked databases relating to truck safety violations and crashes in Illinois, to document the properties of these databases and to create the necessary computer programs so that it becomes possible for future CMV safety trends to be monitored effortlessly.

This chapter describes the research methodology used to fulfill these objectives. In Section 4.2, the method used to estimate exposure measures is describe. Section 4.3 describes the outcome measures considered in the study, including crash rates, inspection violation rates and a combined (inspection-violation/crash) safety index.

4.2 Exposure Method Estimation

The data and database linking issues in estimating exposure measures were described in Chapter 3. In this section, we describe the specific method and procedures used to estimate exposure. In order to describe these procedures, it becomes necessary to consider the details of the data sources involved, since the methods are intricately linked to data availability.

As described in Table 3.4, the study has used three primary sources of data in order to estimate annual miles driven by vehicles in the three categories of CMVs listed in Section 5.1. These are (i) CMV registration data from the Illinois Secretary of State's office. (ii) Illinois Department of Transportation (IDOT's) Annual Vehicle Miles Traveled (AVMT) estimates for trucks. (iii) Truck Inventory and Use Survey (TIUS) collected by the U.S. Census Bureau.

As described in Section 3.4, an average per-vehicle estimate of miles driven (by interstate and intrastate CMVs) was developed, using data from the Truck Inventory and Use Survey (1992), which has detailed data on the physical and operating characteristics of a random sample of private and commercial trucks. The per-mile estimate was "factored" up to the total population of trucks that drove in Illinois in each year. This factoring-up process used Vehicle Registration Data from the Illinois Secretary of State's office.

By introducing minor variations to the basic structure described in the above paragraph, three approaches were used to estimate miles driven by interstate and intrastate CMVs in Illinois. These approaches are called Case I, II and III. These are described below.

Using this process to link together data and estimates from the three sources given in Section 3.4, it was possible to estimate the VMT for interstate and intrastate CMVs in Illinois. This breakdown of VMT was estimated for the years 1993 through 1997, the years considered in this analysis.

4.2.1 Exposure Estimation Process

Three scenarios of interstate and intrastate CMV miles driven within Illinois were estimated. These are described in the following sections.

Case I

Figure 4.1 gives a conceptual depiction of the process by which these 'shares' by different entities (of the total AVMT) were estimated under the first scenario, Case I.

Step A: (i) Estimate average annual miles driven by intrastate CMVs within Illinois. (ii) Factor these averages to the 'population' of intrastate CMVs in Illinois, which in this case is the total number

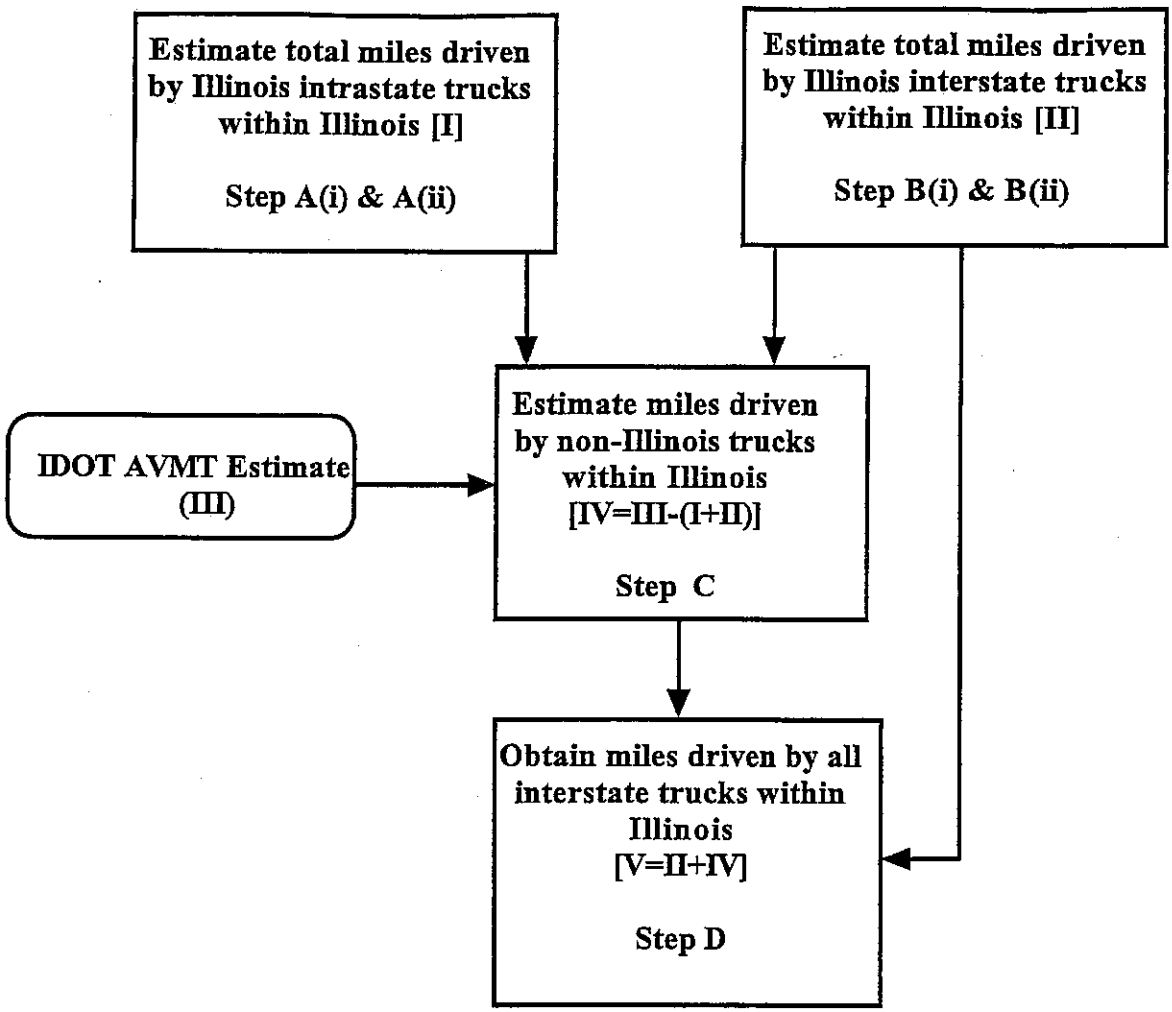


Figure 4.1: Conceptual depiction of estimation of interstate and intrastate CMV mileage within Illinois.

of intrastate CMVs registered in Illinois. This gives us the *total number of miles driven annually by intrastate CMVs registered in Illinois within Illinois (given as (I) in Figure 4.1).*

Step B: (i) Estimate the average annual miles driven by Illinois interstate CMVs within Illinois. (ii) Factor these averages to the 'population' of interstate CMVs in Illinois, which in this case is the total number of interstate CMVs registered in Illinois. This gives us the *total number of miles driven annually by interstate CMVs registered in Illinois within Illinois (given as (II) in Figure 4.1).*

Step C: Subtract (I) and (II) from IDOT's AVMT (given as (III) in Figure 4.1) to obtain *total miles driven by all non-Illinois trucks in Illinois (given as (IV) in Figure 4.1).*

Step D: Obtain *total miles driven by all interstate CMVs within Illinois (given as (V) in Figure 4.1).*

Therefore, the quantities of interest in the study are [I] and [V]. This scenario assumes that the mean number of miles driven by interstate and intrastate CMVs remain the same over time. The data collected by VIUS 1997 may be used to verify if indeed this mean has remained constant over time. However, the microdata from the VIUS 1997, for the state of Illinois, will be available no earlier than the end of this year. Hence, for the purposes of this project, we have to make this assumption.

The annual miles driven by CMVs registered in Illinois was estimated by a model of the form:

$$\text{miles}_i = \alpha_1 x_{i,interstate} + \alpha_2 x_{i,intrastate} + \epsilon_i \tag{4.1}$$

where miles_i are the miles driven within Illinois by the ith CMV and

$$x_{i,interstate} = \begin{cases} 1 & \text{if the } i\text{th CMV is interstate} \\ 0 & \text{otherwise.} \end{cases} \tag{4.2}$$

and

$$x_{i,intrastate} = \begin{cases} 1 & \text{if the } i\text{th CMV is intrastate} \\ 0 & \text{otherwise.} \end{cases} \tag{4.3}$$

The parameters of this model were estimated using Ordinary Least Squares (OLS). Parameters α_1 and α_2 are the mean number of annual miles driven within Illinois by interstate and intrastate CMVs respectively. These parameters were estimated from the TIUS. The subset of data used were commercial vehicles whose base state was Illinois. The results of the estimation process are presented in Chapter 5.

The estimates of α_1 and α_2 were then used to factor up to the total "population" of intrastate and interstate CMVs registered in Illinois which were obtained from the Secretary of State's office. That is:

$$\text{miles}_{IL,y} = \hat{\alpha}_1 \times CMV_{interstate,y} + \hat{\alpha}_2 \times CMV_{intrastate,y} \tag{4.4}$$

where $\text{miles}_{IL,y}$ is the total miles driven in Illinois in year y by CMVs registered in Illinios, $CMV_{interstate,y}$ is the number of interstate CMVs registered in Illinois in year y and $CMV_{intrastate,y}$ is the number of intrastate CMVs registered in Illinois in y.

The next step (Step C) is to use the Annual Vehicle Miles Traveled (AVMT) by CMVs in Illinois ($\text{miles}_{total,y}$) obtained from IDOT [given in Table 5.1] to find out the annual miles driven within Illinois by CMVs registered outside Illinois ($\text{miles}_{non-IL,y}$). This is simply:

$$\text{miles}_{non-IL,y} = \text{miles}_{total,y} - \text{miles}_{IL,y} \tag{4.5}$$

This procedure leads to estimation of:

1. Intrastate CMV miles within Illinois
2. Illinois interstate miles within Illinois
3. non-Illinois interstate miles within Illinois

Case II:

A large share of the intrastate CMVs registered in Illinois are under the Farm category. Many of these tend to be privately owned. The data from the TIUS shows that CMVs used for farm activities are smaller in size and could well be four-tire vehicles. It is also likely that many of these CMVs do not participate in highway travel.

To make the procedure described above compatible with the IDOT AVMT estimates, we estimated miles for the three categories of CMVs without considering farm vehicles to be a part of the intrastate CMV category. This is referred to here as Case II.

Case III:

Case III uses a similar approach as Cases I and II. But with Case II, Instead of estimating the mean number of miles driven by interstate and intrastate CMVs from the TIUS and then factoring the mean mileage to each year's vehicle registration data, we could have simply assumed that the same split in mileage was incurred for each year considered in the study.

In Case III, farm vehicles were included as a part of the sample. But because the rate of intrastate CMV registrations has declined over the years, this approach would lead to an overestimate in the proportion of miles driven by intrastate CMVs over the years.

4.3 Types of Outcome Measures Considered in the Study

The research premise used in this study is that differences in safety consequences of regulatory programs and practices pertaining to interstate and intrastate CMVs are identifiable through a set

of outcome measures. This section describes the outcome measures used in the study.

4.3.1 Crash Indices

There were three crash indices considered in this study:

1. The basic safety performance rates considered in this study is the CMV Involvement Crash Rate defined as:

$$\text{CMV Involvement Crash Rate}_{y,c} = \frac{\text{Number of CMVs involved in crashes}_{y,c}}{\text{Total CMV miles}_{y,c}} \tag{4.6}$$

   where y is the year of analysis, from 1994 to 1997 and c is either interstate or intrastate CMV.

2. The second safety performance rate is the CMV Crash Rate, defined as:

$$\text{CMV Crash Rate}_{y,c} = \frac{\text{Number of crashes involving CMVs}_{y,c}}{\text{Total CMV miles}_{y,c}} \tag{4.7}$$

3. The third safety performance rate considered is the CMV Rate defined as:

$$\text{CMV Fatality Rate}_{y} = \frac{\text{Number of fatalities in crashes involving CMVs}_{y}}{\text{Total CMV miles}_{y}} \tag{4.8}$$

4. Finally, the CMV Fatality Involvement Rate is given by:

$$\text{CMV Fatality Involvement Rate}_{y} = \frac{\text{Number of trucks involved in fatal accidents}_{y}}{\text{Total CMV miles}_{y}} \tag{4.9}$$

   The last two rates were developed used the Fatal Analysis Reporting System (FARS), from which it was not possible to classify trucks as interstate and intrastate. Hence, this is an aggregate rate over all classification of trucks.

4.3.2 Inspection Indices

The following indices compared interstate and intrastate CMVs on the basis of their roadside inspection patterns:

1. The first inspection-related index measures the rate of inspection of interstate and intrastate vehicles and is measured as the number of vehicles in each category inspected as a proportion of all vehicles inspected. This index, Inspection Proportion, is given by:

$$\text{Inspection Proportion}_{y,c} = \frac{\text{Total number of inspections}_{y,c}}{\text{Total number of inspections}_{y}} \tag{4.10}$$

2. The second inspection index attempts to quantity the rate of inspection of different vehicles on a per-mile basis. The Inspection Rate is given by

$$\text{Inspection Rate}_{y,c} = \frac{\text{Total number of inspections}_{y,c}}{\text{Total miles driven}_{y,c}} \tag{4.11}$$

3. The third inspection index gives the Vehicle Out-Of-Service (OOS) Rate for interstate and intrastate vehicles and is given by:

$$\text{Vehicle OOS}_{y,c} = \frac{\text{Total number of vehicle OOS violations}_{y,c}}{\text{Total number of inspections}_{y,c}} \tag{4.12}$$

4. The fourth inspection index is the Driver Out-Of-Service (OOS) Rate for the two categories of vehicles:

$$\text{Driver OOS}_{y,c} = \frac{\text{Total number of driver OOS violations}_{y,c}}{\text{Total number of inspections}_{y,c}} \tag{4.13}$$

Similar measures for developed for each type of carrier considered in the study.

4.3.3 Estimated Aggregate Crash Involvement of Inspected Vehicles

It is useful to know if the relationship between number of violations uncovered during an inspection and the percent of inspected trucks subsequently involved in crashes is different for interstate and intrastate carriers. This may be indicative of the level of "follow-up" actions that are expended to ensure that violations are effectively dealt with. Carrier and vehicle level analysis of this relationship would also indicate the extent to which corrective strategies are undertaken to eliminate safety hazards on the part of vehicle owners. The Combined File described in Chapter 3 was used for this analysis.

Preliminary data visualization indicated that a higher percent of inspected vehicles incurring large number of violations are subsequently involved in crashes. The preliminary analysis seemed to indicate that the percent of inspected vehicles subsequently involved in crashes increases exponentially with the number of violations incurred during the inspection. That is, there is a relationship of the type

$$\text{PERCENT} = \gamma \exp[\lambda \text{VIOLATIONS}] \tag{4.14}$$

holds, where PERCENT gives the percent of inspected vehicles involved in one or more crashes within a year after the inspection and VIOLATIONS give the number of violations incurred during the inspection. There was initial evidence to believe that this exponential relationship holds for both types of carriers.

One objective is to estimate if the intercepts (γ's) and the slopes (λ) are significantly different for interstate and intrastate carriers. For that purpose, the following set of variables are first defined:

$$a_{1,i} = \begin{cases} 1 & \text{if CARRIER2=1 for } i\text{th vehicle} \\ 0 & \text{otherwise.} \end{cases}$$

$$b_{1,i} = \begin{cases} \text{VIO}_i & \text{if CARRIER2=1 for } i\text{th vehicle} \\ 0 & \text{otherwise.} \end{cases}$$

$$a_{2,i} = \begin{cases} 1 & \text{if CARRIER2=0 for } i\text{th vehicle} \\ 0 & \text{otherwise.} \end{cases}$$

$$b_{2,i} = \begin{cases} \text{VIO}_i & \text{if CARRIER2=0 for } i\text{th vehicle} \\ 0 & \text{otherwise.} \end{cases}$$

The model given in Equation 4.14 is then linearized using logarithms. A "parallel" lines linear model of the form in Equation 4.15 may be written

$$\log[\text{PERCENT}]_i = g_1 a_{1,i} + \ell_1 b_{1,i} + g_2 a_{2,i} + \ell_2 b_{2,i} + \epsilon \tag{4.15}$$

where the exponents of g_1 and g_2 are the estimates of γ in Equation 4.14 (for the intercepts for interstate and intrastate carriers respectively) and the exponents of ℓ_1 and ℓ_2 are the estimates of λ (for the slopes for the two types of carriers).

The model is Equation 4.15 allowed us to test the hypothesis:

$$H : g_1 = g_2 \quad \text{versus} \quad A : g_1 \neq g_2 \tag{4.16}$$

which essentially allowed the evaluation of whether the same percent of CMVs belonging to interstate carriers that incurred zero violations during inspections are likely to be involved in crashes compared to CMVs belonging to intrastate carriers. An F test used for this purpose.

Another test that was conducted assessed if the rate of increase in the percent involved in crashes with the increase in the number of violations differed significantly for CMVs belonging to interstate and intrastate carriers. This is a test of significance for the slopes in the model given in Equation 4.15 and is of the form:

$$H : \ell_1 = \ell_2 \quad \text{versus} \quad A : \ell_1 \neq \ell_2. \tag{4.17}$$

An F test was used for this problem as well.

4.3.4 Estimated Combined Vehicle Safety Index

This section describes the development of an index that gives the level of risk or the probability of crash of an inspected vehicle. In order to estimate that risk, the vehicle's crash history, its safety inspection history, an approximate level of exposure (miles driven) of the vehicle and information on its owner-firm is taken into account. This outcome measure is termed the Combined Vehicle Safety Index.

The risk of being involved in a crash varies considerably depending on a number of factors. In Chapter 2 we reviewed the literature and concluded that prior studies have found that traffic operations characteristics such as speed on upgrades, freeway ramp merging and weaving and intersection

maneuvers could impact on CMV crash rates. Further, the effects of driver conditions (including hours-of-service, fatigue and impairment) may also have an effect. One should also look at issues such as the effects of environmental factors such as rain, snow, fog, strong winds and so on. Finally, factors relating to truck configuration (including handling and stability properties as well as weight) have also been analyzed in terms of their impacts of truck crash rates.

The above-mentioned factors, in interaction with factors such as driver error, create the "precursor" conditions to crashes. Any record of a vehicle's crash must be analyzed in the context of these "micro" events that surrounded each crash situation. However, the current study does not deal with these micro event-related factors. The objective in this study, is to find out if there are any "systematic" factors on the part of the regulatory and enforcement process as well as on the part of the carriers and vehicles that lead to crashes. CMV safety inspections are intended to ensure that unsafe vehicles or drivers are either pulled off the road (put Out-Of-Service), corrected at the scene, operate under restricted service or towed away. Hence, the results of the analysis reported here must take cognizance of the fact that the CMV crash may have occurred due to uncontrollable environmental effects, due to errors of the part of the other vehicles involved in the crash and other factors over which the CMV driver or carrier had no control.

In this section, using a Generalized Linear Model approach, estimates were developed of the probability of that an inspected vehicle will be involved in a crash. One issue to remember here is that data on the miles driven by each and every vehicle that was inspected, between the time it was inspected and the time it was involved in a crash, was not available. As a surrogate for that measure, the mean number of miles driven by the an average vehicle (in the same class as the inspected CMV, defined in terms of physical and operational characteristics, that was available from the TIUS) was used in the model. This issue is discussed in greater detail in Section 5.4 of Chapter 5. The model also uses data on the jurisdictional properties of the carrier and the vehicle, level of inspection that was conducted on the vehicle, the number of violations that were incurred, whether OOS violations were incurred and interaction terms between type of carrier and type of CMV and mean miles driven for that vehicle class.

The model estimates the probability of a crash of the ith vehicle and is conceptually of the form:

$$\begin{aligned}\text{Prob[Crash]}_i = f(&\text{Vehicle Characteristics, Carrier Characteristics,}\\ &\text{Vehicle Inspection Violation History, Average Miles Driven})_i.\end{aligned} \tag{4.18}$$

The response variable is 1 or 0 indicating occurrence or lack of occurrence of crashes within a one year window of time after the crash. The mean number of miles were allocated to each vehicle in the Combined File by linking it with the TIUS data. The average annual mileage estimate for each CMV in the Combined File is the average miles driven by CMVs in each state and type of jurisdiction (interstate and intrastate/local). These estimates are given in Chapter 5. The TIUS mean miles per state and jurisdiction of operation and the records in the Combined Files were linked by using the base state of operation in the TIUS and the license state of vehicles in the Combined File.

The response variable is binomial; hence the link function used to model the probability of crashes is logit. The vector of parameters in the model was estimated using a Restricted Maximum Likelihood

Table 4.1: **Variables used in the model.**

[p]

Response Variable:

$$\text{ACC}_i = \begin{cases} 1 & \text{if the } i\text{th CMV was involved in a crash within} \\ & \quad \text{a year of being inspected} \\ 0 & \text{otherwise.} \end{cases}$$

Explanatory Variables:

$$\text{CMV2}_i = \begin{cases} 1 & \text{if the } i\text{th CMV is interstate*} \\ 0 & \text{otherwise.} \end{cases}$$

$$\text{Carrier2}_i = \begin{cases} 1 & \text{if the } i\text{th CMV belongs to interstate carrier*} \\ 0 & \text{otherwise.} \end{cases}$$

Age at inspection: Age of the vehicle when inspected

Number of Violations: Count of all violations incurred when ispected

Mile: Average miles defined on the basis of state of registration of vehicle and type of operation (defined in Chapter 4)

$$\text{Inspection Level}_i = \begin{cases} 1 & \text{for FULL inspection} \\ 2 & \text{for WALK AROUND} \\ 3 & \text{for DRIVER ONLY} \\ 4 & \text{for SPECIAL ROAD} \\ 5 & \text{for TERMINAL.} \end{cases}$$

$$\text{Driver OOS}_i = \begin{cases} 1 & \text{if driver of } i\text{th vehicle is placed Out-of-Service} \\ 2 & \text{otherwise.} \end{cases}$$

$$\text{Vehicle OOS}_i = \begin{cases} 1 & \text{if } i\text{th vehicle is placed Out-of-Service} \\ 2 & \text{otherwise.} \end{cases}$$

*: See definitions given in Chapter 4.

Chapter 5

Exposure Measures

5.1 Background Findings on Exposure Measures

This chapter presents the findings on estimation of exposure measures. Relevant background data and information are summarized in Section 5.2. The mileage estimates obtained are presented in Section 5.3. Trip length distributions of interstate and intrastate CMVs are discussed in Section 5.4.

The correct estimation of appropriate exposure measures is critical in crash and safety history studies. This fact applies to the current study as well. Since the study is comparing the crash rates and inspection violation rates of two groups of vehicles (interstate and Illinois intrastate CMVs), care must be taken not to overestimate or underestimate the exposure of one group relative to the other because that could have a strong impact on the result of the comparisons.

For this study, the estimate of miles driven, for each year of analysis, by (i) CMVs registered as interstate and intrastate and (ii) carriers designated as interstate and intrastate. Individual vehicles may be registered for conducting interstate or intrastate commerce. However, an interstate carrier may own vehicles that are licensed to conduct commerce within a state only. In this case, while the carrier is interstate, the vehicle is intrastate. The situation is further complicated by the fact that a vehicle registered as intrastate may be allowed to travel out of state under special permit.

At the vehicle level, the study has to estimate the following: (A.i) miles driven by interstate CMVs registered in Illinois within Illinois (A.ii) miles driven by interstate or intrastate CMVs registered in states other than Illinois within Illinois and (A.iii) miles driven by intrastate CMVs registered in Illinois within Illinois. For the purposes of this study:

1. Categories (A.i) and (A.ii) may be grouped as *miles driven by interstate CMVs within Illinois* and

2. Category (A.iii) may be considered as *miles driven by intrastate CMVs within Illinois.*

At the carrier or firm level, miles driven within Illinois may be incurred by the following categories: (B.i) CMVs belonging to interstate carriers domiciled in Illinois (B.ii) CMVs belonging to interstate or intrastate carriers domiciled in other states and (B.iii) CMVs belonging to intrastate carriers within Illinois. Again for the purposes of this study:

1. Categories (B.i) and (B.ii) may be grouped as *miles driven by CMVs belonging to interstate carriers within Illinois* and
2. Category (B.iii) may be assigned as *miles driven by CMVs belonging to intrastate carriers within Illinois.*

5.2 Background Findings on Exposure Measures

Table 5.1 gives the total number of vehicles registered as interstate or intrastate in Illinois, from the years 1993 to 1997 (note that the numbers in bold for years 1993 and 1994, for interstate CMVs, are our projections based on the rate of growth in the interstate CMV registrations in later years). These data were obtained from the Secretary of State's Office.

Table 5.1: **Commercial Vehicle Registrations in the State of Illinois: 1993 through 1997.**

	Intrastate CMV Registrations				Interstate CMV Registrations		
Year	Farm	Flatweight	Mileage Tax	Total	For-hire	Commercial	Total
1993	30,251	126,071	21,414	177,736	NA	NA	**99,804**
1994	30,488	128,760	21,674	180,922	NA	NA	**112,140**
1995	30,463	133,443	21,541	185,717	NA	NA	126,463
1996	29,810	136,431	21,229	187,470	NA	NA	140,520
1997	29,480	139,045	20,846	189,371	NA	NA	155,269
1998	29,125	140,236	20,754	190,115	149,703	17,933	167,636

Source: Illinois Secretary of State's Office.

Intrastate CMVs are apportioned into three groups: (i) Farm Category: these CMVs can leave the state if they need to and under generally allowed into other states under reciprocity arrangements (ii) Flatweight Category: these CMVs can enter another state if they buy that state's registration or a trip permit and (iii) Mileage Tax Category: these CMVs can enter another state if they buy that state's registration or a trip permit. Interstate CMVs can enter another state on a regular basis. They are categorized into for-hire CMVs and commercial CMVs.

Each state is required to estimate the Vehicle Miles Traveled (VMT) by different functional categories of vehicles. IDOT estimates VMT of several different categories of CMVs using Highway Performance Monitoring System (HPMS) procedures. Our objective is to ascertain the share of these total CMV miles that are driven by CMVs in the different categories described above in Section 5.1.

Currently, IDOT estimates Annual Vehicle Miles of Travel (AVMT) by 13 different categories of vehicles. The IDOT numbers we have presented are AVMT for the following types of vehicles:

1. single unit trucks
   (a) 6-tire
   (b) 3-axle
2. multiple unit trucks
   (a) 3-axle
   (b) 4-axle
   (c) 5-axle
   (d) 6-axle

In addition to the physical characteristics of trucks, the IDOT AVMT estimates are also available by type of roadway facility. Table 5.2 gives the estimated AVMT by each category of truck described above, along with the totals for the years 1993 through 1997.

Table 5.2: **Annual Vehicle Miles Traveled (AVMT) by all categories of trucks within Illinois.**

Year	Annual Truck Vehicle Miles Traveled (in millions)
1993	7,454
1994	8,559
1995	9,595
1996	9,665
1997	10,435

Source: Illinois Travel Statistics, 1993 through 1997. Illinois Department of Transportation.

The 1992 TIUS has data on 2,362 trucks registered in Illinois. After 'matching' the TIUS definitions of a truck with those of the crash, inspection and IDOT AVMT definitions [using criteria of type of vehicle and weight of the vehicle], the TIUS data yielded on a total of 1,756 trucks in Illinois. Out of these, 742 vehicles were engaged in "for-hire" business. It is important to remember that whereas most motor carriers are classified into operational types for-hire, private or independent

owner-operators, the TIUS classifies for-hire trucks into motor carrier, private or independent. To avoid confusion and to be consistent with the State of Illinois vehicle registration definitions, all trucks that are engaged in commercial vehicle activity are called as Commercial Motor Vehicle (CMV). The study has considered the sample of 742 CMVs an adequate size for the purposes of this study.

From the TIUS, the total 1992 annual miles driven by all trucks registered in Illinios was estimated to be 11,541,463,120 miles. This includes mileage incurred in states other than Illinois. This may be compared to an estimated 119,772,736,474 miles driven by all trucks throughout the United States in 1992.

5.3 Mileage Estimates

In Chapter 4, three approaches to estimating mileage were discussed. In the following sections, the results of the three approaches are presented.

5.3.1 Case I:

The results of the model in Equation 4.1 in Chapter 4 is given in Table 5.3. The parameters in that modelα_1 and α_2 are the mean number of annual miles driven within Illinois by interstate and intrastate CMVs respectively. These parameters were estimated from the TIUS. The subset of data used were commercial vehicles whose base state was Illinois.

Table 5.3: **Mean number of annual miles driven by interstate and intrastate CMVs within Illinois.**

Parameter	Estimate	Standard Error
α_1	22,506	791.61
α_2	32,833	1,346.17
	$R^2 = 0.70$	
	$s = 16,376.91$	

The estimate of α_1 gives the mean number of miles driven by interstate trucks in Illinois. Interstate CMVs drive an average of 22,506 miles per year within Illinois, compared to intrastate CMVs, which drive an average of 32,833 miles per year within Illinois. But the standard errors of the estimate of $\hat{\alpha_2}$, the average for the intrastate CMVs is far greater than that of $\hat{\alpha_1}$, the average for the interstate CMVs.

The estimates were then used to factor up to the total "population" of intrastate and interstate CMVs registered in Illinois which were obtained from the Secretary of State's office, using Equation 4.4 in Chapter 4. The next step (Step C) was to use the Annual Vehicle Miles Traveled (AVMT) by

Illinois by CMVs registered outside Illinois, using Equation 4.5 in Chapter 4. This procedure allowed the estimation of (i) intrastate CMV miles within Illinois (ii) Illinois interstate miles within Illinois and (iii) non-Illinois interstate miles within Illinois. The last two quantities are together constitute interstate miles within Illinois.

These estimates are shown in Figure 5.1. In 1993, intrastate trucks drove an estimated 4,200 million miles more than interstate trucks in Illinois. By 1995, intrastate trucks drove about 2,600 million miles more than interstate trucks. By 1997, the difference had reduced to about 2,000 million miles.

The total annual miles driven by intrastate trucks is greater partly because the number of registered intrastate trucks is far greater than interstate trucks. Further, the annual trip lengths of intrastate trucks driven within Illinois is, on the average, almost 10,000 miles greater than that driven by interstate trucks within Illinois. The sum of the miles driven by the interstate trucks registered in Illinois and interstate trucks from outside is estimated to be lower than intrastate trucks for all years examined.

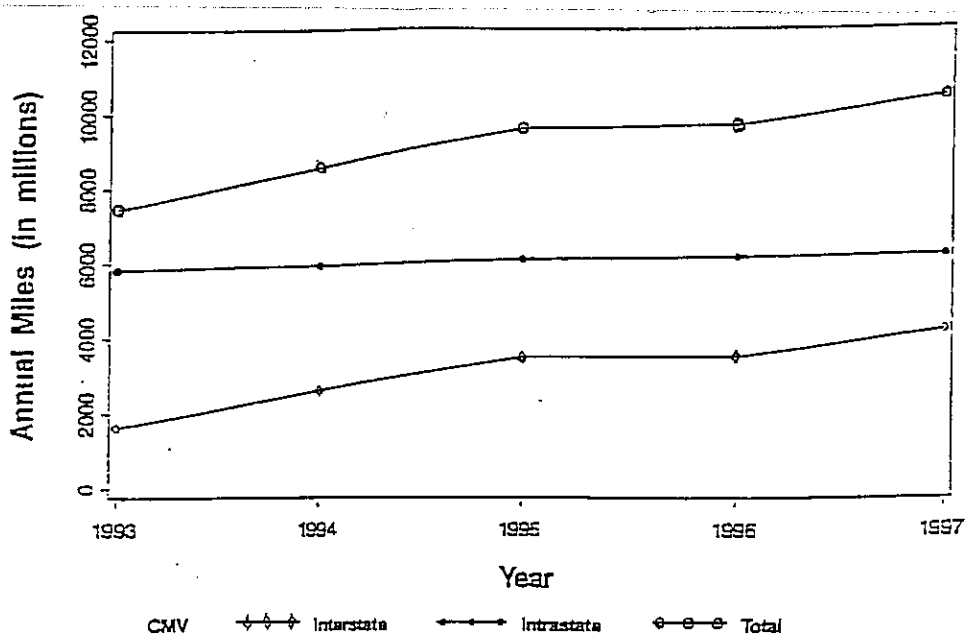


Figure 5.1: Miles driven by interstate and intrastate CMVs. Case I.

5.3.2 Case II:

As discussed in Chapter 4, under Case II, the mileage for the three categories of CMVs were estimated by excluding farm vehicles from the intrastate CMV category. These estimates are shown in Figure 5.2.

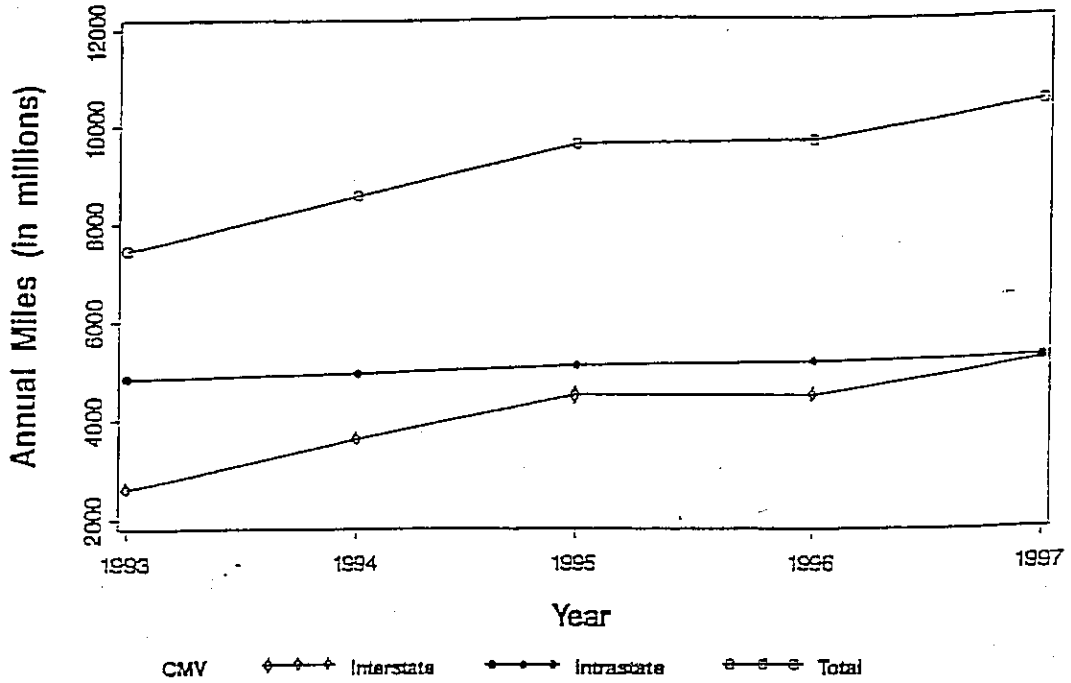


Figure 5.2: Miles driven by interstate and intrastate CMVs. Case II.

The pattern of increase in mileage is the same for Cases I and II. But under this set of assumptions, interstate trucks drive more over time. In 1993, intrastate trucks are estimated to drive about 2230 million miles more than interstate trucks; by 1997, interstate trucks were driving about 64 million miles more than intrastate trucks.

5.3.3 Case III:

As discussed in Chapter 4, Case III assumes that the same split in mileage was incurred for each year considered in the study. However, there were problems with this estimation approach. Because the rate of intrastate CMV registrations have declined over the years, this approach led to an overestimate in the proportion of miles driven by intrastate CMVs over the years.

5.3.4 Mileage Estimates Used in Study

For the purposes of this study, it had to be determined which would be the best set of assumptions to use in order to apportion IDOT AVMT estimates into that incurred by interstate and intrastate CMVs. It was determined that Case I would be the most appropriate approach to determining interstate and intrastate CMV mileage.

Compared to Case II, the study does not categorically exclude a portion of the vehicle fleet, especially

because it could not be determined with reasonable certainty the reasons why farm vehicles, although mostly privately owned, should be excluded. Case III was determined to be unreasonable because that approach would force the mean number of miles driven by interstate trucks over the years to be too low and totally unreflective of the fact that interstate CMV registration were increasing at a strong rate over time and that the rate of increase in intrastate CMV registration was comparatively lower.

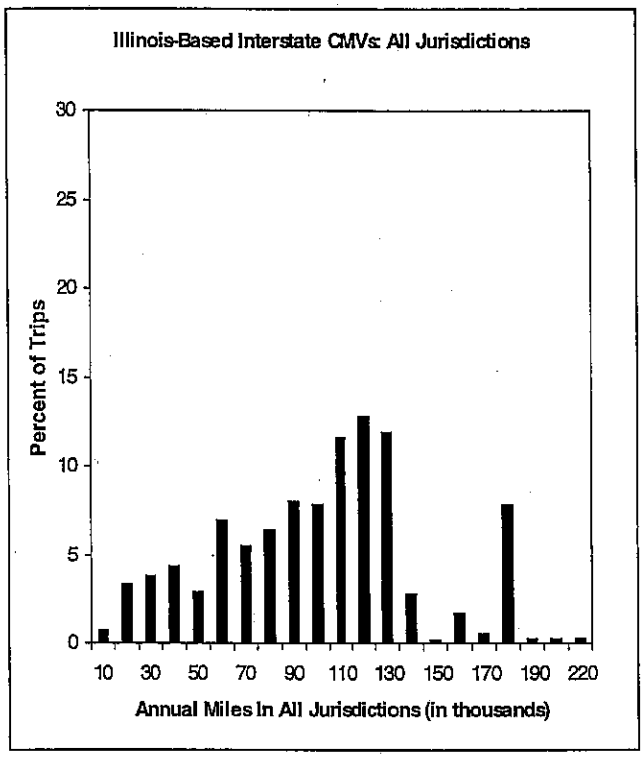
5.4 Trip Length Distributions and Mean Miles in Vehicle Index Analysis

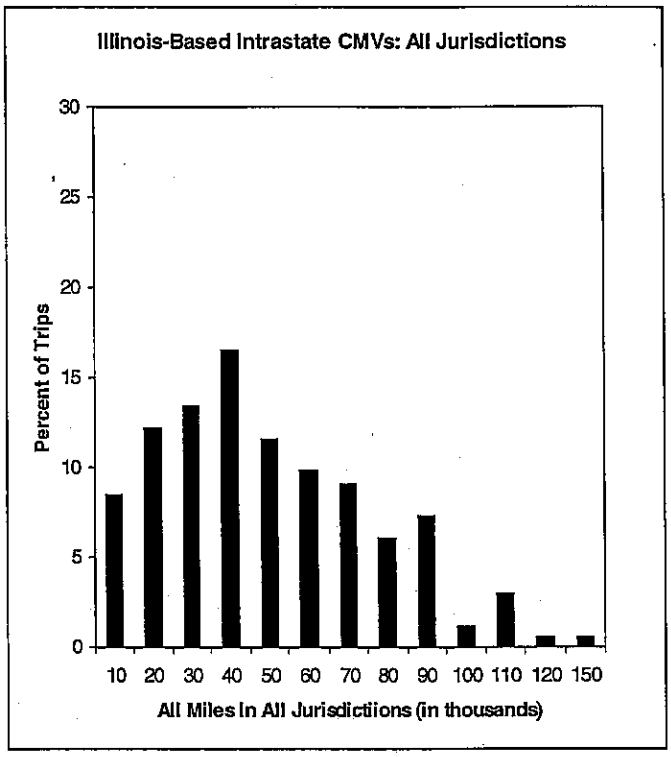
Figure 5.3 gives the trip length distributions of interstate and intrastate CMVs based in Illinois. The data were obtained from the Truck Inventory and Use Survey (1992). These are total miles driven, irrespective of jurisdiction. As can be expected, the distribution for the interstate CMVs are more wide than intrastate CMVs. However, intrastate CMVs also tend to incur high mileage, but this type of vehicle probably drive more over a smaller area. This conjecture is borne out to be true when we compare the two top figures with the two bottom figures.

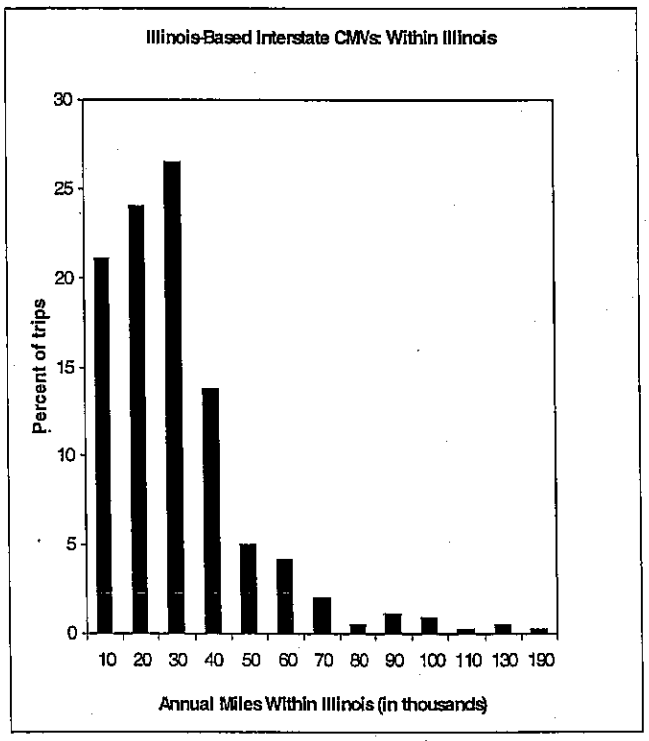
The two bottom figures give the trip length distributions of Illinois CMVs (interstate and intrastate) within Illinois only. This was possible to estimate from the TIUS, because data are available on the percentage of total miles incurred by a CMV in a year outside the home base state of the CMV. It can be seen that the two distributions for intrastate CMVs are similar, whereas the distribution for within-Illinois mileage by interstate CMVs is quite a bit narrower than mileage over all jurisdictions.

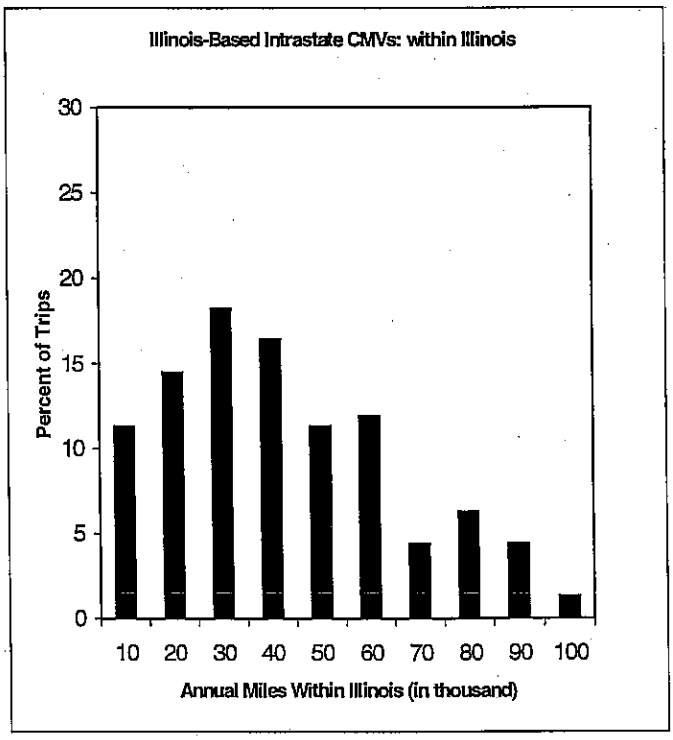
The data in the Combined File (which was described in Chapter 3) will be finally used to estimate the probability of crashes, using the procedures outlined in Section 4.3.4 of Chapter 4. As described in Section 4.3.4, each inspected vehicle in that file was assigned a value, which is the average miles driven by CMVs in each state and type of jurisdiction (interstate and intrastate/local). The TIUS mean miles per state and jurisdiction of operation and the records in the Combined File were linked by using the base state of operation in the TIUS and the license state of vehicles in the Combined File.

Table 5.4 gives the mean number of miles driven by interstate and intrastate (intrastate+local) CMVs driven in all jurisdictions by state. There are large geographical differences in the distribution of miles of interstate and intrastate CMVs throughout the United States. Except for Hawaii and Alaska, the differences are in the range of 30,000 to 60,000 miles. The average difference in Illinois is 54,735 miles.









Source: Truck Inventory and Use Survey. Bureau of Census.

Table 5.4: **Miles driven by interstate and interstate (and local) trucks in the United States.**

State	FIPST	Mean Miles driven by interstate trucks	Mean miles driven by intrastate and local trucks	Difference
AK	2	34225.88	27609.29	6616.59
AL	1	96598.83	51620.69	44978.15
AR	5	86457.07	53280.99	33176.09
AZ	4	80352.15	35991.92	44360.24
CA	6	81396.24	45161.68	36234.56
CO	8	86544.52	36356.66	50187.86
CT	9	50560.21	26126.08	24434.14
DC	11	76462.06	25585.33	50876.73
DE	10	62030.65	24105.92	37924.73
FL	12	84350.04	46250.36	38099.68
GA	13	93622.55	46253.78	47368.78
HI	15	28099.67	22233.12	5866.56
IA	19	97390.89	36968.74	60422.15
ID	16	91216.51	32188.68	59027.83
IL	17	93693.65	38957.88	54735.78
IN	18	93522.19	45267.01	48255.19
KS	20	93704.47	48234.44	45470.03
KY	21	76417.63	37653.91	38763.73
LA	22	79240.01	46179.51	33060.50
MA	25	58680.53	40558.87	18121.67
MD	24	66228.79	30886.02	35342.77
ME	23	93810.31	48923.93	44886.38
MI	26	74175.60	41572.64	32602.96
MN	27	94815.81	43968.58	50847.23
MO	29	103312.76	40252.30	63060.47
MS	28	80268.05	43634.96	36633.10
MT	30	97971.98	30222.91	67749.08
NC	37	93965.09	37918.98	56046.11
ND	38	98477.24	39098.77	59378.47
NE	31	96241.02	47172.28	49068.74
NH	33	66571.75	28607.15	37964.60
NJ	34	68308.36	33786.56	34521.81
NM	35	37487.85	24365.11	13122.74
NV	32	74338.91	31503.84	42835.07
NY	36	72822.82	31670.34	41152.49
OH	39	81797.88	43852.48	37945.40
OK	40	90326.08	41090.10	49235.99
OR	41	86391.01	41006.51	45384.50
PA	42	83886.63	36411.09	47475.55
RI	44	62905.19	25632.36	37272.83
SC	45	79330.91	38785.35	40545.56
SD	46	96031.07	45838.57	50192.50
TN	47	99089.17	54282.11	44807.07
TX	48	91069.31	43847.53	47221.78
UT	49	105871.44	55256.49	50614.95
VA	51	64200.34	34879.79	29320.55
VT	50	89191.57	31393.40	57798.18
WA	53	68907.67	31146.84	37760.84
WI	55	96989.42	36182.61	60806.82
WV	54	77685.71	35993.04	41692.68
WY	56	81951.73	38637.47	43314.27

Source: Truck Inventory and Use Survey, 1992.

Chapter 6

Results

6.1 Background

This chapter discusses the results of this study. Discussion of the findings in terms of the objectives of the study will be deferred till the next chapter, Chapter 7. The presentation of results in this chapter will be on the outcome measures described in Chapter 4.

In Section 6.2 we discuss crash indices. Inspection violation indices are discussed in Section 6.3. The estimated aggregate crash involvement rates of inspected vehicles are discussed in Chapter 6.5. Finally, the combined safety index is discussed in Section 6.6.

6.2 Crash Rates

There were 74,526 trucks involved in crashes in Illinois between 1994 and 1996. The yearly breakdown is given in Table 6.1. The CMV Crash Rate, defined in Equation 4.6of Chapter 4 as number of CMVs involved in crashes in Illinois divided by total truck miles in Illinois, is given in the third column of the table. Although three years is too small a time frame to draw any conclusions, these figures are consistent with crash involvement rates at the national level.

The fourth column gives the number of crashes that occurred in Illinois, in which one or more trucks were involved. This number reduced by almost 11,240 from 1994 to 1997. The next column is the CMV Crash Rate, which is given by Equation 4.7. This number has reduced over 3.23 to 1.69 over the three years. The last two columns give the crash involvement rates over the same time period for all states in the U.S. but separately for light and heavy trucks. Heavy trucks in their definition includes only trucks over 10,000 lbs. in gross vehicle weight (GVW). The definition of trucks in this study include all trucks in the appropriate categories as obtained from the IDOT Crash Files, some

Table 6.1: **Total crashes involving trucks and crash rates in Illinois from 1994 to 1996.**

Year	Total CMVs Involved in Crashes	CMV Crash Rate (million miles)	Crashes Involving Trucks	CMV Involvement Crash Rate (million miles)	National Truck Crash Rate (million miles) Light Trucks	Heavy Trucks
1994	29,348	3.43	27,666	3.23	3.83	2.61
1995	27,561	2.87	26,142	2.72	3.95	2.03
1996	17,617	1.82	16,426	1.69	NA	NA
Total	74,526	-	70,234	-		

of which may be less than 10,000 lbs. Hence, the Illinois CMV Crash Rate numbers are somewhere between the light and heavy truck crash rates at the national level.

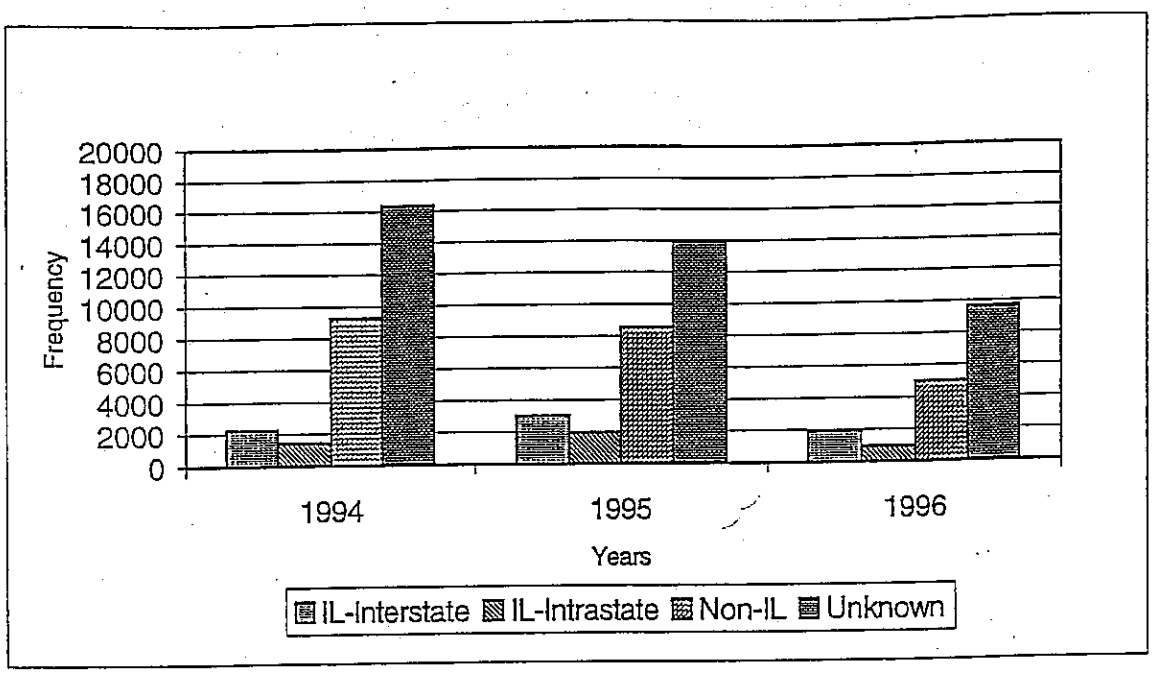
Trucks in the IDOT Crash File could be identified as interstate or intrastate based on their Vehicle Identification Numbers (VINs). If the VIN is not available for a truck in the IDOT Crash File, then the jurisdictional identity of that truck is not known. But even if a truck in the IDOT Crash File has a VIN, if that VIN is not present in the Master Identification Database that is created, then the jurisdictional identity of that truck is still not known. Table 6.2 gives the availability of VINs in the IDOT Crash File for the years 1994 through 1996.

Table 6.2: **Yearly breakdown of availability of Vehicle Identification Numbers in the IDOT Crash File.**

Year	Has VIN	Does Not Have VIN	Total Trucks
1994	22,151	7,197	29,348
1995	21,925	5,636	27,561
1996	14,568	3,049	17,617
Total	58,644	15,879	74,526

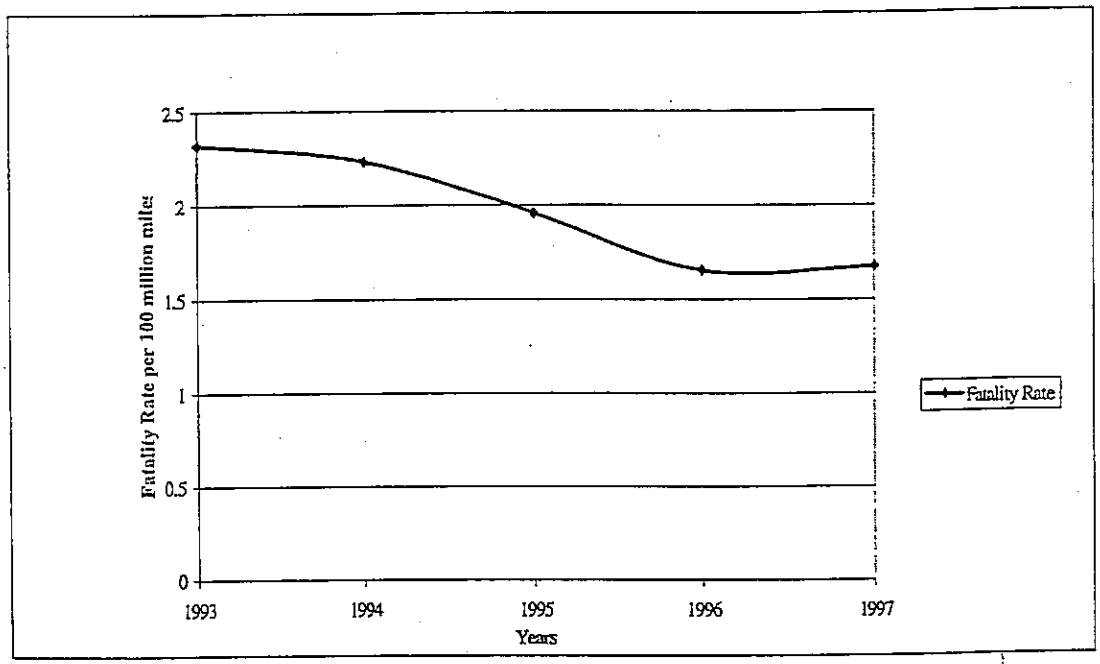
Table 6.2 gives an idea of the "classifiable" trucks involved in crashes in Illinois. About 54% of the trucks cannot be classified. In the presence of this data limitation, no attempt to estimate crash rates for interstate and intrastate trucks in Illinois is made. Rather, Figure 6.1 shows counts of trucks in the four categories (i) Illinois interstate (ii) Illinois-other and intrastate (iii) non-Illinois CMVs and (iv) unknown is produced. For each of the three years considered, the greatest number of CMVs are those which could not be correctly identified as Illinois interstate, Non-Illinois interstate or intrastate and Illinois intrastate CMVs. Of the identified trucks involved in crashes, over 30% were licensed outside Illinois, about 10% were large CMVs licensed in Illinios for interstate commerce and 6% were Illinois CMVs in the "Other" category.

Figure 6.2 shows the CMV Fatality Rate (given in Equation 4.8 of Chapter 4) for all CMVs in Illinois



Source: IDOT Crash File and the Master Identification Database.

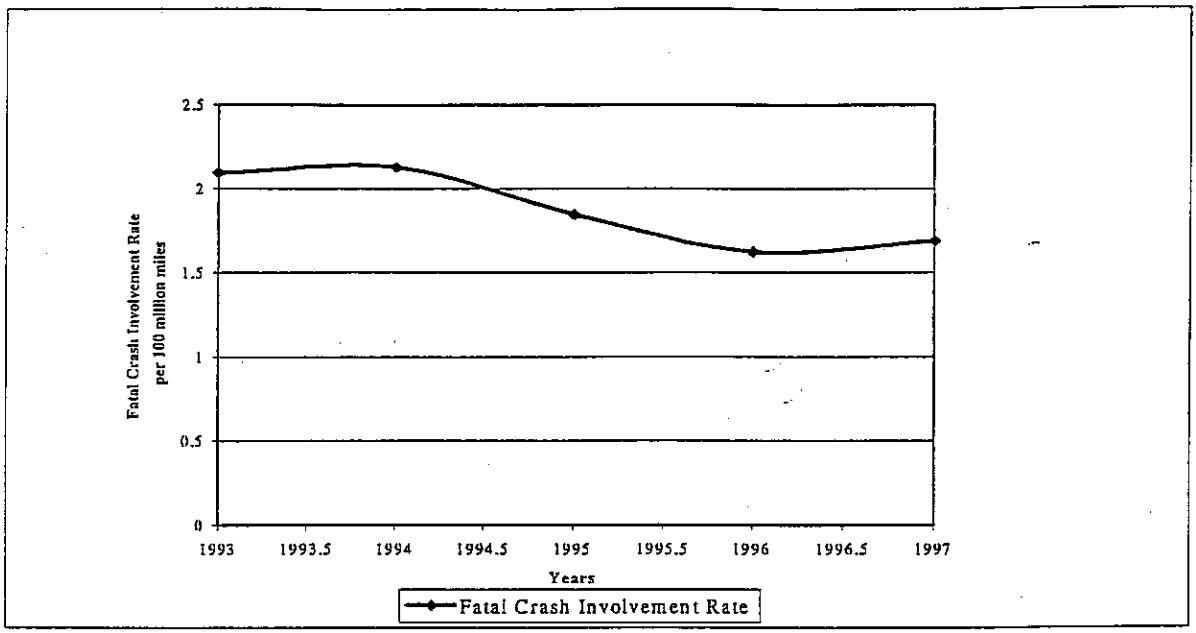
Figure 6.1: Classification of CMVs involved in crashes in Illinois.



Source: FARS, NHTSA, 1993 through 1997.

Figure 6.2: CMV Fatality Rate in Illinois.

for the period between 1993 and 1997. This rate has been declining steadily since 1993, with a rapid decline between 1994 and 1996, after which the rate seems to have stabilized.



Source: FARS, NHTSA, 1993 through 1997.

Figure 6.3: CMV Fatal Crash Involvement Rate in Illinois.

Figure 6.3 gives the CMV Fatal Crash Involvement Rate (which is given by Equation 4.9). The figure indicates a slight upward increase in the year 1997, up from 1996; this indicates that the number of fatalities per truck involved in fatal crashes has increased slightly. This may be a temporary increase; a more conclusive statement can be made only after observing more years of data.

6.3 Inspection Violation Rates

Commercial vehicle inspection violations in Illinois were examined using the ISP Inspection Files. This is a relational database and is very 'clean' in terms of its ability to allow us to categorize CMVs as interstate or intrastate or carriers as interstate or intrastate. As described in Section 4.3.2 of Chapter 4 Section 4.3.2, different index measures were developed to estimate the Inspection Violation rates.

The first finding here is that intrastate CMVs tend to be inspected at a lower rate than interstate vehicles. Equation 4.10 in Section 4.3.2 gives the Inspection Proportion of all vehicles inspected. Table 6.3 shows the (I) year, (II) total number of inspections or interstate and intrastate vehicle units, (III) total number of inspections of interstate and intrastate vehicles by lead vehicle type (to

be discussed in the paragraphs below). Over the five years analyzed, about 54% of the vehicle units inspected were (Non-Illinois) interstate. Together with interstate vehicle units registered in Illinois, inspections of all interstate vehicle units constituted almost 75% of all inspections. The proportion of inspections made on vehicle units of different jurisdictional categories remained more or less constant over the 5 years.

Table 6.3: **Number of inspections by vehicle unit type.**

I.	II. Total Inspection for Vehicle Unit Type				III. Inspection for Lead Vehicle Type			
Year	IL-Interstate	Intrastate & Other Illinois	Non-IL Interstate	Total	IL-Interstate	Intrastate & Other Illinois	Non-IL Interstate	Total
1993	7820	10938	20359	39,117	7780	4049	9337	21,166
	20.0	28.0	52.0	100.0	19.89	10.35	23.87	54.11
1994	37357	51862	107923	197,142	37078	19720	51276	108,074
	18.9	26.3	54.7	100.0	18.81	10.00	26.01	54.82
1995	39357	54902	118939	213,198	39134	20942	57466	117,542
	18.5	25.8	55.8	100.0	18.36	9.82	26.95	55.13
1996	34314	47613	95827	177,754	34149	17973	46125	98,247
	19.3	26.8	53.9	100.0	19.21	10.11	25.95	55.27
1997	34263	47346	96176	177,785	34125	14915	45100	94,140
	19.3	26.6	54.1	100.0	19.19	8.39	25.37	52.95

Table 6.4: **Rate of inspections.**

I.	II. Vehicle Unit Inspection Rate (per million mile)		III. Proportion of total inspections		IV. Lead Vehicle Inspection Rate (per million mile)	
Year	Intrastate & Other Illinois	Illinois Interstate	Intrastate & Other Illinois	Illinois Interstate	Intrstate & Other Illinois	Illinois Interstate
1993	1.87438	17.4109	0.27962	0.72038	0.69385	10.5760
1994	8.73079	55.4743	0.26307	0.73693	3.31979	33.7375
1995	9.00391	45.2607	0.25752	0.74248	3.43448	27.6203
1996	7.73551	37.0785	0.26786	0.73214	2.92001	22.8709
1997	7.61491	30.9283	0.26631	0.73369	2.39886	18.7850

A second index is the Inspection Rate of interstate or intrastate CMVs. This is given by Equation 4.11 of Chapter 4. Miles driven by interstate vehicles in Illinois have been increasing over time (see Chapter 5). From 1993 through 1997, the annual miles driven by interstate trucks more than doubled, whereas annual miles driven by intrastate trucks is estimated to have increased at a much slower rate. The inspection rates of interstate and intrastate vehicle units are shown in Table 6.4 under Item II. The rate increased very sharply for both interstate and intrastate vehicle units from 1993 to 1994. After a period of high inspection rates over 1994 and 1995, the rate decreased again by 1996. But throughout all the years analyzed, the rate of inspection of interstate vehicle units is far greater than inspection of intrastate vehicle units.

But before an inspection rate can be estimated, a technical issue arises due to which an adjustment has to be made to the inspection numbers. It may be recalled that IDOT estimated AVMT for trucks

with different configurations – in fact, 6 vehicle types. In the IDOT system, a vehicle with several axles may actually be a vehicle with a power unit such as the truck tractor and one or more trailers. If this entire vehicle (the tractor and two trailers) drives one mile, then the VMT for that vehicle is 1 mile. On the other hand, the different units of the vehicle are treated separately in the ISP Inspection Files. During an inspection, each unit of a vehicle (for example, the power unit, trailer number 1, trailer number 2) are inspected and the data (on violations and so on) of each unit are entered in the Vehicle File. The counts given under Items II of Table 6.3 reflect the number of units in the vehicle; for example, the vehicle described above will be counted as three vehicle units. To continue with the above example, if all three units are interstate and all three units were inspected, then the count entered is 3 for the interstate category; if 2 out of the 3 units are inspected, then a count of 2 inspections is entered; if all 3 units are inspected and one unit is intrastate, then a count of 2 is entered under interstate and a count of 1 entered under intrastate. The inspection rates given under Items II and III of Table 6.4 are reflective of vehicle units.

On the other hand, Item (III) in Table 6.3 gives the number of CMVs inspected, irrespective of the number of units in that CMV. In this case, a CMV with 3 separate units count as 1 CMV. The problem here, of course, is that if the units belong to different interstate/intrastate categories, then which category should the total CMV be assigned would be the question. It was decided that the category of the lead unit should determine the assignment. Only truck tractors or straight trucks can be lead vehicle units. Therefore Item III in Table 6.3 gives the number of interstate and intrastate lead vehicles inspected. Only about 8% of CMVs had a lead vehicle which is intrastate. Even on a per million miles driven basis (Item IV in Table 6.4), the rate of inspection of CMVs where the lead vehicle is interstate is about 10 times that of intrastate lead vehicle CMV inspection.

Table 6.5: **Table for Vehicle Out-of-Service.**

		VEH-OOS by the type of CMV			
		Illinois	Intrastate & Other	Non-IL	
Year	Variable	Interstate	Illinois	Interstate	Total
1993	N	764	1800	1423	3987
	OOS(%)*	9.77	16.46	6.99	10.19
1994	N	2878	7410	6597	16885
	OOS(%)	7.70	14.30	6.12	8.57
1995	N	2678	6859	5539	15076
	OOS(%)	6.80	12.50	4.66	7.07
1996	N	2589	6946	5026	14561
	OOS(%)	7.55	14.60	5.25	8.20
1997	N	3442	8726	7394	19562
	OOS(%)	10.05	18.44	7.69	11.01

*: Percent of all vehicles inspected.

The third index is the Vehicle Out-Of-Service given by Equation 4.12. About 9% of the vehicles inspected were found to be Out-Of-Service (OOS) over the time period examined. The rate of

Vehicle OOS for all vehicle units have remained more or less constant over the five years. Table 6.5 shows that Intrastate vehicle units constitute the greatest percent of all vehicle OOS. Vehicle OOS was lowest for intrastate units for 1995 (at about 13% of all vehicles inspected) having dropped from about 16% of all inspected vehicles; however the percent of intrastate vehicle OOS of all vehicle units inspected increased to about 18% in 1997.

Table 6.6: **Driver Out-of-Service for interstate and intrastate CMVs.**

		DRIVER OOS by the type of CMV				DRIVER OOS proportion for lead vehicle type		
Year	Variable	Illinois Interstate	Intrastate & Other	Non-IL Interstate	Total	Illinois Interstate	Intrastate & Other	Non-IL Interstate
1993	N	266	421	1240	1927	0.034190	0.10398	0.13280
	OOS(%)*	0.68	1.08	3.17	4.93	-	-	
1994	N	1259	2005	6636	9900	0.033955	0.10167	0.12942
	OOS(%)	0.64	1.02	3.37	5.02	-	-	
1995	N	1275	2027	6918	10220	0.029488	0.09442	0.11456
	OOS(%)	0.60	0.95	3.24	4.79	-	-	
1996	N	1007	1697	5284	7988	0.029488	0.09442	0.11456
	OOS(%)	0.57	0.95	2.97	4.49	-	-	
1997	N	1185	2327	5501	9013	0.034725	0.15602	0.12197
	OOS(%)	0.67	1.31	3.09	5.07	-	-	

*: Percent of all vehicles inspected.

The fourth inspection index considered is the Driver Out-Of-Service for the two categories of vehicles given by Equation 4.13. Table 6.6 gives the Driver OOS for Interstate and Intrastate CMVs. The Driver Out-of-Service rates remained at about 5% of all inspected vehicle units from 1993 through 1997. This is the percent of all vehicle units driven. Drivers of non-Illinois interstate CMVs incurred the greatest Driver OOS rates. This rate also remained about the same over the 5 years. Drivers of intrastate CMVs incurred the second highest OOS rates of all vehicles inspected each year. About 10% of the CMVs with an intrastate lead vehicle incurred Driver OOS compared to 3% of Illinois interstate lead vehicles and 13.28% of non-Illinois interstate lead vehicles.

Similar indices have been developed for each type of carrier. Table 6.7 gives the share of inspections of CMVs belonging to interstate and intrastate carriers. It needs to be noted here that if a CMV belonging to an intrastate carrier domiciled in California is inspected, that carrier appears an intrastate carrier in the above table, whereas the vehicle would appear an interstate CMV in the previous discussions. Further discussions regarding the issue of classifying carriers into interstate and intrastate categories are discussed in Section 6.6.

The rate of inspection of CMVs belonging to intrastate carriers decreased from 10.4% in 1993 to 6.6% in 1997 with concurrent increases in CMVs belonging to interstate carriers. During the same time, intrastate carriers incurring OOS violations as a percent of all vehicles that were inspected increased from 7.97% in 1993 to 8.37% in 1997. Interstate carriers incurring vehicle OOS violations as a percent of all vehicles that were inspected remained about the same during this period. As a

Table 6.7: **Number of inspections and Vehicle OOS by carrier type.**

Year	Variable	I. Inspection for Carrier Type			II. Vehicle OOS			III. Driver OOS		
		Interstate	Intrastate	Total	Interstate	Intrastate	Total	Interstate	Intrastate	Total
1993	N	26807	3098	29905*	2829	247	3076	1401	141	1542
	%	89.6	10.4	100.0	10.55**	7.97	10.29	4.68	0.47	5.16
1994	N	143823	21413	165236*	12350	1831	14181	7475	934	8409
	%	87.0	13.0	100.0	8.59	8.55	8.59	4.52	0.57	5.09
1995	N	184781	23348	208129*	12743	1960	14703	8890	1021	9911
	%	88.8	11.2	100.0	6.90	8.40	7.07	4.27	0.49	4.76
1996	N	106281	11102	117383*	7951	963	8914	4848	415	5263
	%	90.5	9.5	100.0	7.48	8.68	7.60	4.13	0.35	4.48
1997	N	94770	6670	101440*	9948	558	10506	4639	258	4897
	%	93.4	6.6	100.0	10.50	8.37	10.36	4.57	0.25	4.83

* Frequency Missing
1993 : 9,212
1994 : 31,906
1995 : 5,069
1996 : 60,371
1997 : 76,345

** Percent of all vehicles inspected.

percent of all vehicles inspected, drivers of intrastate carriers incurred higher driver OOS rates (at about 5% of all vehicles inspected) than interstate carriers.

6.4 Crashes and Inspections

Figure 6.4 gives the percent of inspected trucks which were subsequently involved in (one or more) crashes. The data depicted in the figure is from the Combined File. The figure shows that the percent of trucks that were subsequently involved in crashes is relatively invariant to a certain number of violations incurred. However, a much larger percent of trucks that incurred 14 or higher number of violations were involved in crashes.

From an enforcement point of view, it is important to be able to detect and remove vehicles with very high violation rates from service. It may also be necessary that vehicles with a great number of violations be appropriately inspected before being allowed to get back to service. Several enforcement document types may emerge from an inspection, including arrest citation, an inspection report, overweight citation or a written warning. Hence safety inspections identity potential problems with operating circumstances of the vehicle. Further, carriers are subject to compliance review process and given safety ratings. All these regulatory actions should, if they are truly effective, lead to a

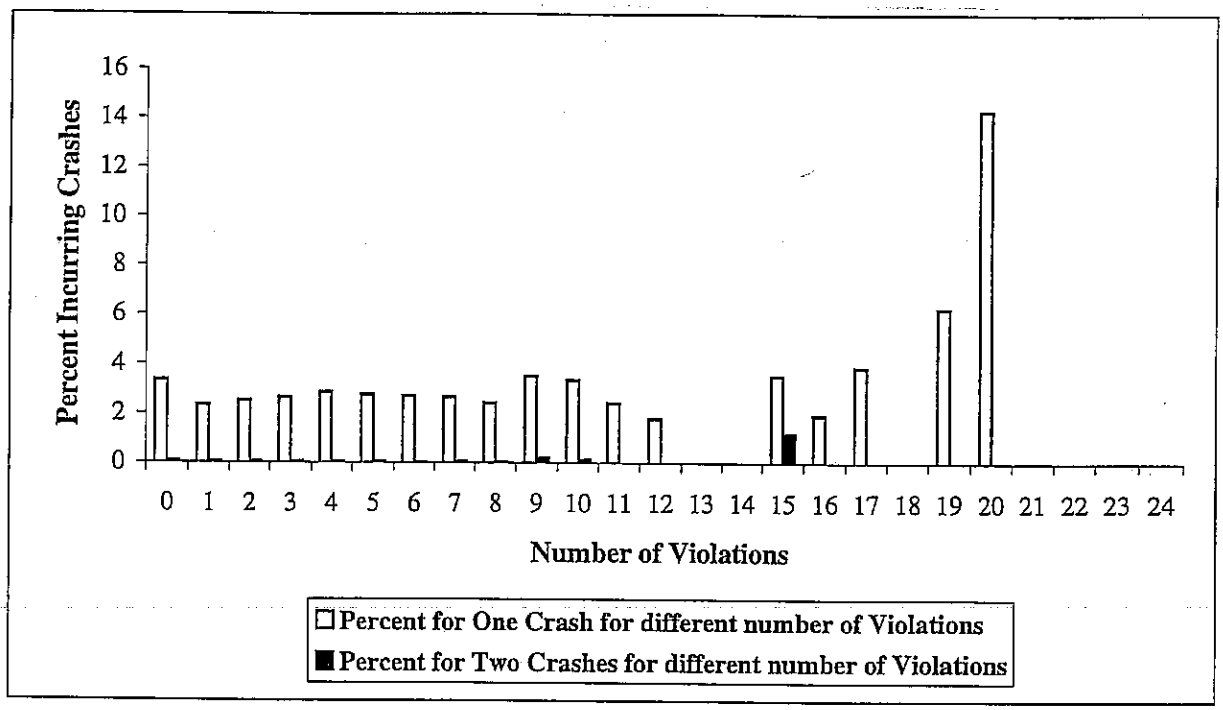


Figure 6.4: Percent of inspected trucks involved in crashes.

lowered risk of crashes of vehicles and carriers that have been inspected.

6.5 Aggregate Crash Involvement of Inspected Vehicles

The estimated aggregate crash involvement of inspected vehicles yielded some important results. Section 4.3.3 in Chapter 4 describes the procedure involved in estimating the crash involvement. The analysis indicated that the percent of inspected vehicles subsequently involved in crashes increases exponentially with the number of violations incurred during the inspection. The crashes considered here are DOT-reportable crashes only; that is crashes involving trucks in which there is at least one fatality or one injury where the person has to be taken to a medical facility and/or a vehicle has to be towed away from the scene.

Table 6.8 gives the results of the analysis conducted on the carrier-level crash percent of inspected vehicles. The estimates are of the parameters in Equation 4.15.

Table 6.8: **Carrier crash percent of inspected vehicles.**

Parameter	Estimate	Standard Error	Parameter	Estimate*
g_1	0.51	0.20	γ_1	1.67
g_2	1.27	0.23	γ_2	3.57
ℓ_1	0.09	0.02	λ_1	1.09
ℓ_2	-0.13	0.03	λ_2	0.89

R^2=0.89 Root MSE=0.44

* This estimate is simply the exponent of the estimates in the second column.

The intercept for interstate carriers is estimated to be 1.67, that is, 1.67% of the trucks belonging to interstate carriers which incurred 0 violations during inspections are involved in crashes within a year of the inspection. However, the intercept for trucks belonging to intrastate carriers is estimated to be 3.57, which means that about 4% of the intrastate carrier vehicles which incurred 0 violations are involved in crashes within a 1 year time period after the inspection.

It is interesting to speculate why a greater percent of intrastate carrier vehicles with 0 violations are estimated to incur crashes subsequent to the inspection. Figure 6.4 clearly shows that vehicles that incur large number of violations are more likely to incur crashes. One reason for a higher crash percent for intrastate carrier vehicles with 0 violations may be that these vehicles are subject to more hostile driving conditions than interstate carrier vehicles. Intrastate carrier vehicles include local trucks and vehicles that operate over short distance and are also likely to operate more frequently in congested urban areas, which offers greater potential for conflict while driving.

An F test of significance was conducted to test the hypothesis stated in Equation 4.16. The test indicated that the intercepts are significantly different at the .10 level (with $p = 0.0578$).

The estimate of slope parameters indicate that the percent involvement in crashes increase at the rate of 1.09% with each increase in the number of violations for CMVs belonging to interstate carriers. The rate of increase for CMVs belonging to intrastate carriers is lower, at 0.88%.

This result is indicative of the fact that the "crash potential" of CMVs belonging intrastate carriers is more invariant with respect to inspection violations. That is, it is not so much that the safety violations make a difference to the likelihood that these vehicles will be involved in crashes as much as their driving conditions. Difficult driving conditions create a uniform potential for crashes irrespective of whether or not the vehicles and the carriers are inherently risky.

The difference in the slope parameter for the two types of carriers was tested using the hypothesis presented in Equation 4.17. The slope parameters for the two carriers are significantly different with an F value of 29.54 and $p = 0.0001$.

Graphical outputs from the estimated model are given in Figure 6.5(A) and (B). The first figure show the estimated percent of crashes plotted against actual percent. The points hug the 45 degree lie, indicating that the fit is sufficient. The second figure shows the percent of inspected vehicles estimated to incur crashes for the two types of carriers. Figure 6.5(B) shows that at an aggregate level, a smaller percent of the inspected vehicles belonging to intrastate carriers would be involved in crashes. Figure 6.5(C) and (D) show a similar analysis at the level of vehicles.

6.6 Combined Vehicle Safety Index

The results of the model presented in Section 4.3.4 is discussed next. The summary statistics for each of the explanatory variables, for each of the two levels of the response variable ACC, is given in Table 6.9. Of all vehicles inspected, 2.6% were involved in at least one crash within a year's time window. The table also shows that the average age of vehicles involved in a crash within a year of inspection is slightly lower, at about 8 years, compared to those that were not found from the Combined Database to have incurred a crash within that time (at about 9 years). The mean number of violations of vehicles involved in crashes is actually slightly lower than those not involved in crashes, at 1.57 compared to 2. However, we already know from the earlier analysis that it is the higher tail of the distribution of violations that makes a difference with crashes. The mean OOS Driver and OOS Vehicle rates are close to 2 for both vehicles that do and do not incur crashes within the one year window indicating that these variables will not be likely to be very useful in estimating probabilities of crashes. Finally, vehicles that incur crashes were subject to slightly lower standards of inspection [Level 1 inspections standards are the most stringent and Level 5 inspections are in-terminal]. Thus, it appears from these summary statistics that CMVs that were involved in a crash were subject to slightly less stringent inspection standards than those which were not involved in crashes during the observation period.

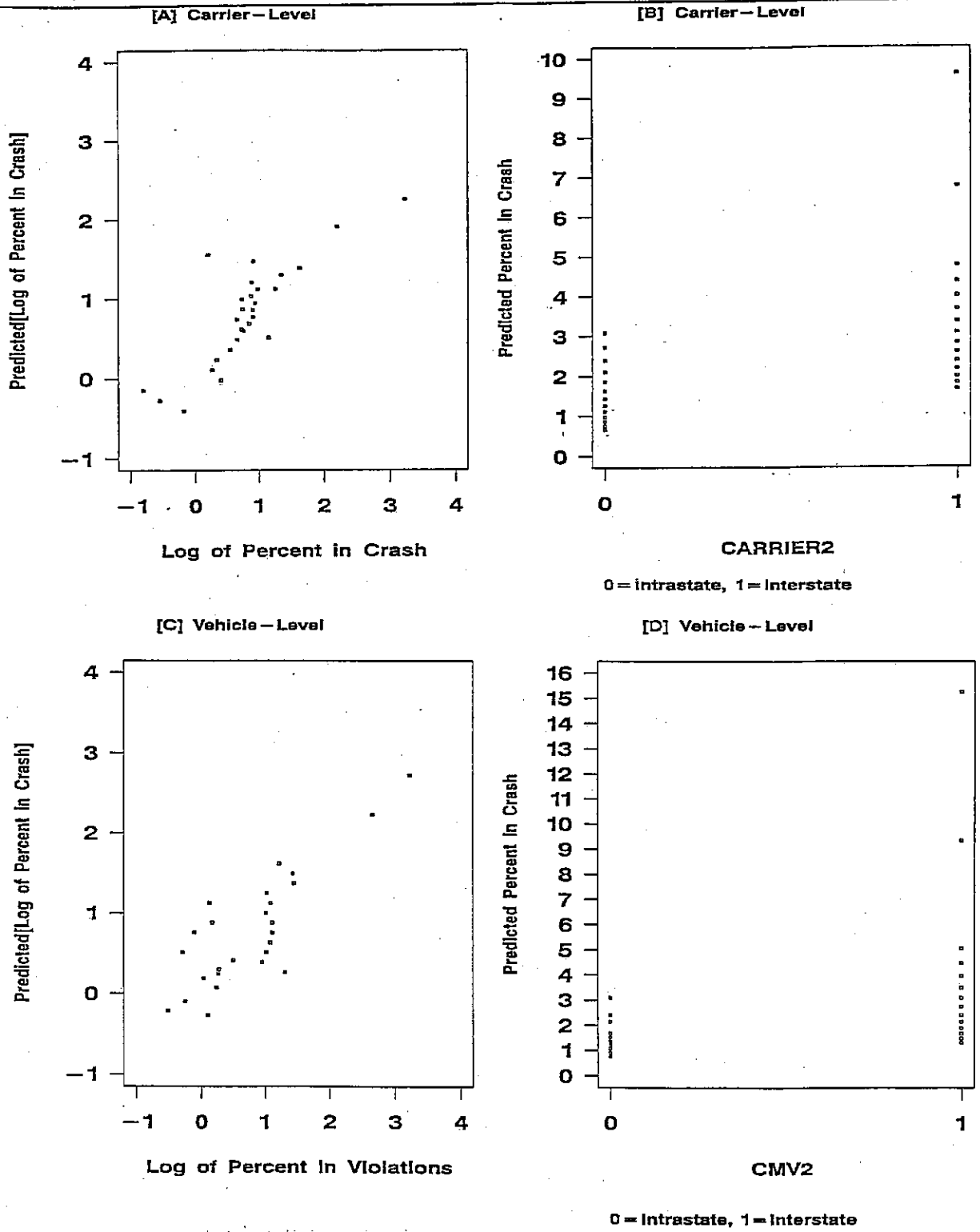


Figure 6.5: Graphical outputs from model relating violations to percent of vehicles in crashes.

Table 6.9: **Descriptive statistics for main effects.**

	ACC	Proportion		
	1	.026		
	0	.974		
	ACC=0		ACC=1	
Explanatory Variable	Mean	Standard Deviation	Mean	Standard Deviation
Age at inspection	8.76	7.18	7.74	4.70
Number of violations	2.04	3.04	1.57	2.48
OOS Vehicle [=1,2]	1.83	0.37	1.86	0.34
OOS Driver [=1,2]	1.93	0.25	1.93	0.24
Inspection Level [=1,2,3,4,5]	2.20	0.77	2.70	0.97

The results of the model are given in Table 6.9. The χ^2 ratio is close to 1, indicating that the model has a good fit. The over-dispersion parameter ϕ is also close to 1, indicating that we have no evidence of over-dispersion (or under-dispersion). Technical issues relating to the model are presented in Appendix E of this report.

Table 6.10: **Estimated model of probability of crash.**

Effect	Estimate	Std Error	t	Pr $> \|t\|$
Intercept	-5.68	0.5945	-9.57	0.0001
Age at inspection	-0.01	0.0084	-1.45	0.1480
Number of violation	-0.02	0.0226	-1.07	0.2840
Vehicle OOS	-0.28	0.1473	-1.96	0.0499
Driver OOS	-0.12	0.1977	-0.63	0.5285
Inspection Level	0.74	0.0561	13.31	0.0001
CMV2× [mile/100000]	1.84	0.3683	5.01	0.0000
CARR× [mile/100000]	-0.52	0.1760	-3.00	0.0022

$$\chi^2 = 14577.11, \quad df = 19563, \quad \chi^2/df = 0.75, \phi = 1.07$$

The vehicle age effect indicates that the probability of a crash increases with decreased age. This is probably an effect of the fact that the risk of a crash increases with increased mileage. Interstate carriers that have vehicles which drive long distances have younger vehicles in their fleet. Further, an increase in the number of violations lead to a very slight decline in crash probability, although that effect is not significant. It appears that the number of violations (which includes all types of violations including driver violations) is not a good predictor of the crash probability of individual vehicles. The number of violations or citations incurred by the carrier should, under ideal circumstances, be introduced in the model; the problem with this, of course, is that this data is not compiled for intrastate carriers.

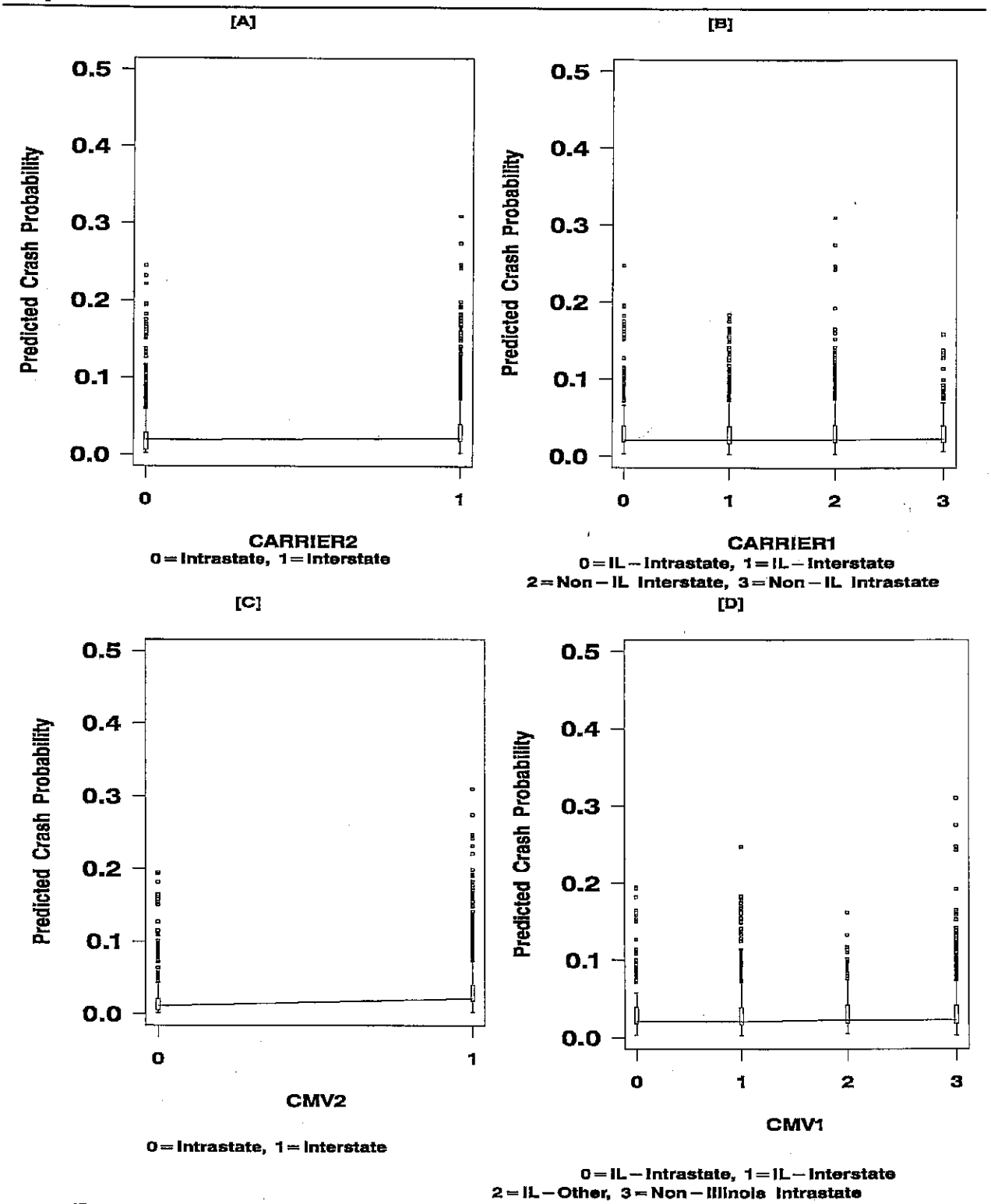


Figure 6.6: Boxplots of crash probabilities for different types of carriers and vehicles.

The interaction effects are significant, indicating that the effect of the type of carrier and the type of vehicle on crash events are different for the same distance traveled. Although the mileage used here are the average of the vehicle class and there may be wide variability within the same vehicle class, the basic trend is that there are carrier and vehicle class differences, when holding miles driven for the class constant.

Figure 6.6 shows the predicted crash probabilities of the different types of vehicles and different types of carriers considered in the study. The predicted points are overlaid with boxplots with lines connecting the median probability of crash for the entities considered in each graph. The figure shows that the median crash probability for all the four categories considered (i) CARRIER1 and CARRIER2 and (ii) CMV1 and CMV2 are about the same. However, the spread of points differs.

For example, from Figure 6.6[A], it can be seen that the distribution of crash probabilities are about the same for intrastate and all interstate carriers, defined by the variable CARRIER2. But when CARRIER2 is broken down into its component parts, it can be seen from Figure 6.6[B] that the distribution of crash probabilities for vehicles belonging to Non-Illinois interstate carriers is quite a great deal wider than for the other types of carriers. The median crash probability is also slightly higher for Non-Illinois interstate carriers, compared to the others.

The median crash probability is slightly higher for CMV2=1 or for interstate carriers. When detailed classifications of CMVs are considered, as in Figure 6.6[D], we see that the widest distribution of crash probabilities are for Non-Illinois intrastate vehicles. Illinois interstate and Illinois intrastate vehicles have about the equal spread of crash probability — the distribution is "tighter" for vehicles in the Illinois-Other category. The reader will recall that this category of vehicles include smaller (less than 26,000 lbs) vehicles belonging to interstate carrier or interstate vehicles belonging to Illinois intrastate carriers.

Figure 6.7[A] depicts the crash probabilities against various exploratory factors. Here too, the predicted points are overlaid with boxplots with lines connecting the median probability of crashes. The median crash probability increases as inspection levels go from 1 to 5; this graphically shows what we found earlier that less stringent inspections lead to a higher crash occurrence.

Figure 6.7[B]The median crashes probabilities are about the same for inspections that led to driver violations with a decrease in vehicle age [as seen from Figure 6.6[C]] while there is an increase in the median with the vehicle class mileage. Finally, there is a slight increase in crash probability as mileage for the class of vehicle (defined in terms of the state of registration of the vehicle) increases.

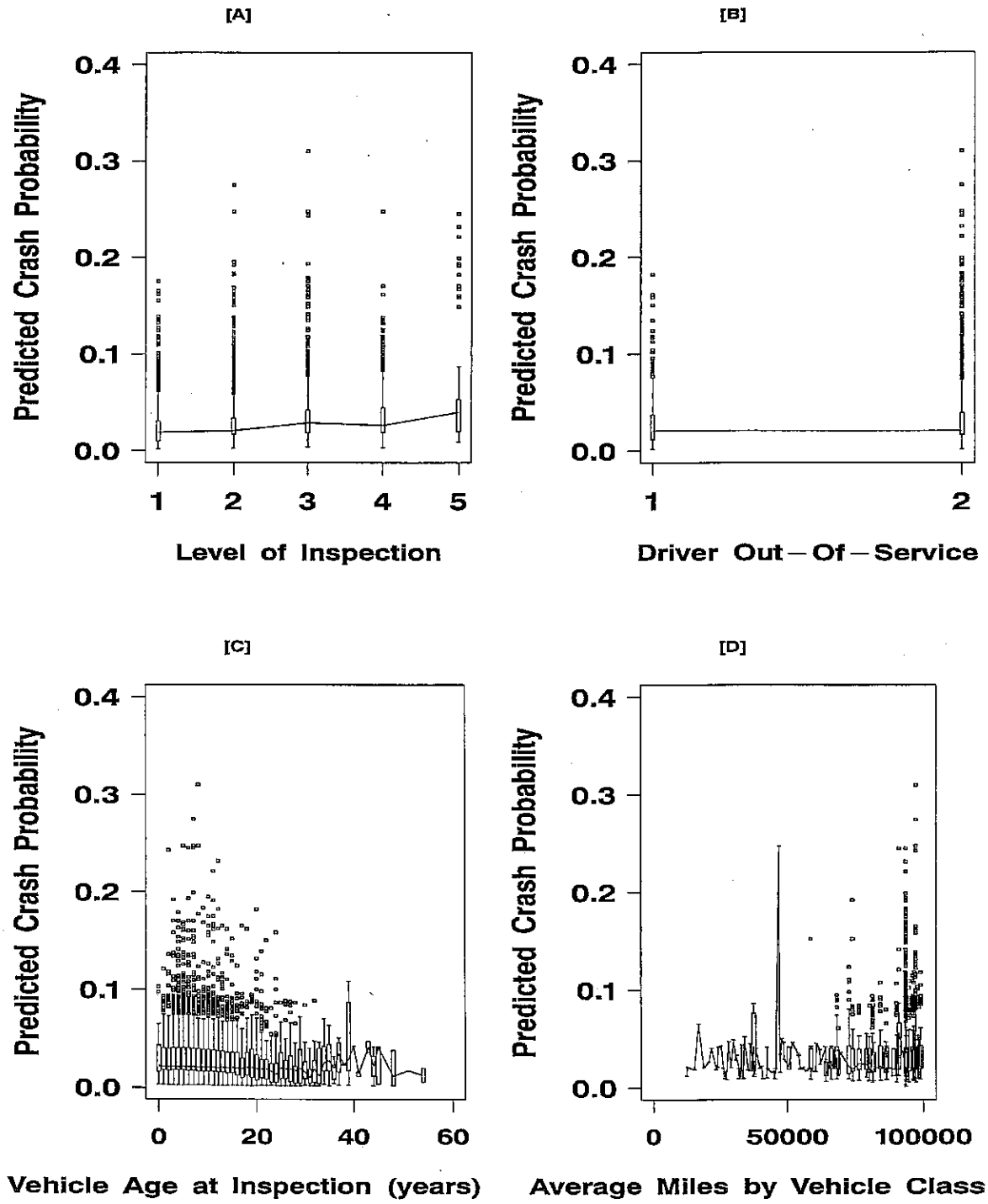


Figure 6.7: Boxplots of crash probabilities by different exploratory effects.

Chapter 7

Conclusions

7.1 Introduction

The following research objectives were considered in the study:

1. To provide a descriptive summary of Illinois intrastate and interstate truck safety violations and crash patterns in Illinois.
2. To determine the extent of difference, if any, between the safety records of interstate CMVs and Illinois intrastate CMVs.
3. To evaluate relevant crash, commercial motor vehicle inspection and exposure databases in terms of their usefulness in analyzing the differences.
4. To create linked databases relating to truck safety violations and crashes in Illinois, to document the properties of these databases and to create the necessary computer programs so that it becomes possible for future CMV safety trends to be monitored effortlessly.

These objectives can be categorized into two major groups: those that pertain to the database issues that arise in studying interstate and intrastate CMV safety history and those that relate to the safety patterns themselves. Consequently, the conclusions of the study are presented in two parts: results relating to data linking (given in Section 7.2) and results emerging from the analysis of the data considered (given in Section 7.3).

used the MID to identify vehicles in the IDOT crash file. The IDOT File was linked to the MID using Vehicle Identification Numbers (VINs). About 53.76% of the CMVs in the IDOT Crash File [from 1994 through 1996] and the carriers to which these CMVs belonged to, could not identified as interstate or intrastate. The reason that the MID had no information on these vehicles present in the IDOT Crash File could be due to the fact that these vehicles were never inspected or had crashes, they were never inspected or had crashes within the time period on the basis of which the MID database was created or because they were inspected or had a crash outside Illinois, but the state where they incurred the crash or was inspected did not upload the data to the federal databases.

4. About 18,307 of the 726,567 vehicle units with complete identifier and inspection history records could be linked to crashes. These crashes occurred in all states within the U.S. within a one year time window after the date of inspection. There is a potential of increasing the time window but much greater computing prowess would be needed for this purpose.

5. The estimated miles driven by interstate CMVs within Illinois are increasing at a much greater rate than intrastate CMVs. Whereas in 1993, about 21.71% of truck miles driven within Illinois were by interstate trucks, the percent mileage of total truck mileage by interstate trucks had gone up to almost 40.41% by 1997. In 1997, the total miles driven by trucks was about 7,454 million. Of this, about 1,618 million miles were driven by interstate trucks and 5,835 million miles by intrastate trucks. The total truck miles had risen to 9,595 million by 1995. In the last year of the analysis, 1997, the total truck miles had gone up to about 10,435 miles, with 4,217 million by interstate trucks and 6,217 million by intrastate trucks.

7.3 Analysis Results

The major conclusions from the analysis conducted in this study are as follows:

1. Between 1993 and 1997, both the CMV Fatality Rate and the Fatal Crash Involvement Rate in Illinois dropped from about 2.2 per 100 million miles driven down to about 1.8 per 100 million miles driven.

2. Between 1994 and 1996, there were 74,526 trucks involved in crashes in Illinois. The Illinois crash involvement rates mirror the trends at the national level. The truck crash rate, given by the number of crashes involving trucks divided by miles driven by trucks was 3.23 in 1994, 2.72 in 1995 and 1.69 in 1996. This rate is somewhere between the light and heavy truck crash rates at the national level.

3. Because 54% of the vehicle or carrier could not be identified, no conclusive finding could be drawn from this study regarding differences in crash rates of interstate and Illinois intrastate CMVs and interstate and intrastate carriers. This fact leads to an immediate need to enhance data collection and entry methods, if the data are looked upon as the basis for informed policy-making.

4. Of all the CMVs that were inspected in Illinois, a large percent were subsequently involved in crashes, in Illinois as well as in other states. Of all the vehicles that were involved in crashes within a year's time window after being inspected, about 13% were vehicles belonging to Illinois interstate carriers, 35% to Illinois intrastate carriers, 47.2% all the Non-Illinois interstate carriers and about 5% to intrastate carriers domiciled outside Illinois. In contrast, of all the vehicles that were not involved in crashes, about 15% were vehicles belonging to Illinois interstate carriers, 29% to Illinois intrastate carriers, 53% all the Non-Illinois interstate carriers and about 4% to intrastate carriers domiciled outside Illinois.

5. Roughly 1.67% of the trucks belonging to interstate carriers which incurred 0 violations during inspections are involved in crashes within a year of the inspection. However, about 4% of the intrastate carrier vehicles which incurred zero violations are involved in crashes within a 1 year time period after the inspection. An F test of significance indicated that the estimates of crash percentages for 0 violations are significantly different at the .10 level (with $p = 0.0578$).

6. A much greater percent of vehicles which incur high rates of violations (12 or more) are subsequently involved in crashes. Of all the vehicles that incurred 12 or more violations, almost 58% were vehicles belonging to Illinois interstate carriers, 22% to Illinois intrastate carriers, 18% to Non-Illinois interstate carriers and 2% to Non-Illinois interstate carriers. The mean number of violations of vehicles involved in crashes is actually slightly lower than those not involved in crashes at 1.57 compared to 2. However, it is the higher tail of the distribution of violations that makes a difference with crashes.

7. Of all the CMVs that were inspected, the percent of interstate CMVs that would be subsequently involved (within a year) in crashes is significantly different from the percent of inspected intrastate CMVs. Further, inspected interstate CMVs are more likely to be involved in (DOT-reportable) crashes within a one-year window compared to intrastate CMVs. This result is not weighted by appropriate exposure measures.

8. The percent involvement in crashes increase at the rate of 1.09% with each increase in the number of violations for interstate carriers. The rate of increase for trucks belonging to intrastate carriers is lower, at 0.88%. The parameters for the two carriers are significantly different with an F value of 29.54 and $p = 0.0001$.

9. About 1% of interstate vehicles with no violations are involved in crashes within a year of the inspection. The model used estimated that 0.77% of intrastate CMVs with no violations during inspections are subsequently involved in crashes. An F test indicated no significant difference in the estimates.

10. The percent involvement in crashes increase at the rate of 1.31% with each increase in the number of violations for interstate CMVs and at the rate of 1.06% for intrastate vehicles. These estimates are not significantly different at the .05 level (with $p = 0.21$).

11. Inspection rates (per million miles driven) are higher for interstate CMVs compared to intrastate CMVs. In the five years of inspection data analyzed, about 54% of the vehicle units (power unit and trailer) inspected are Non-Illinois interstate. Together with Illinois interstate vehicle units analyzed, inspections of all interstate vehicle units constituted almost 75% of all inspections.

12. The Driver Out-of-Service rates remained at about 5% of all inspected vehicle units from 1993 through 1997. Drivers of non-Illinois interstate CMVs incurred the greatest Driver OOS rates. This rate also remained about the same over the 5 years. Drivers of intrastate CMVs incurred the second highest OOS rates of all vehicles inspected each year.

13. The rate of inspection of CMVs belonging to intrastate carriers decreased from 10.4% in 1993 to 6.6% in 1997 with concurrent increases in CMVs belonging to interstate carriers. During the same time, intrastate carriers incurring OOS violations as a percent of all vehicles that were inspected increased from 7.97% in 1993 to 8.37% in 1997.

14. Interstate carriers incurring vehicle OOS violations as a percent of all vehicles that were inspected remained about the same during this period.

15. As a percent of all vehicles inspected, drivers of intrastate carriers incurred higher driver OOS rates (at about 5% of all vehicles inspected) than interstate carriers.

16. Inspected vehicles that are subsequently involved in (DOT-reportable) crashes are likely to be younger than those that are not involved in crashes. The average age of vehicles involved in a crash within a year of inspection is slightly lower, at about 8 years, compared to those that were not found from the Combined Database to have incurred a crash within that time (at about 9 years).

    The mean number of violations of vehicles involved in crashes is actually slightly lower than those not involved in crashes – at 1.57 compared to 2. However, we already know from the earlier analysis that it is the higher tail of the distribution of violations that makes a difference with crashes. The mean OOS Driver and OOS Vehicle rates are close to 2 for both vehicles that do and do not incur crashes within the one year window indicating that these variables will not be likely to be very useful in estimating probabilities of crashes. Finally,

17. Vehicles that incur crashes were subject to slightly lower standards of inspection [Level 1 inspections standards are the most stringent and Level 5 inspections are in-terminal]. Thus, CMVs that were involved in a crash were subject to slightly less stringent inspection standards than those which were not involved in crashes during the observation period.

18. The interaction effects of miles driven by the class of carrier [defined by state of domicile and jurisdiction of operation] are significant, indicating that the effect of the type of carrier on crash events are different for the same distance traveled. Thus there are differences in crashes, when holding miles driven for the class constant. For both types of carriers [interstate and intrastate] there is an increase in the median probability of crash [as determined by a statistical model] with the vehicle class mileage.

19. Median crash probability were estimated on the basis of type of inspection, number of violations, records of vehicle or driver Out-Of-Service violations and interaction effects between carrier/vehicles and class miles driven for the different categories of carriers – Illinois interstate, Illinois intrastate, Non-Illinois interstate and Non-Illinois intrastate are about the same. The medians are about the same for vehicles belonging to all four types of carriers. However, the spread of points differ. The distribution of crash probabilities for vehicles belonging to

Non-Illinois interstate carriers is wider than for the other types of carriers. The median crash probability is also slightly higher for Non-Illinois interstate carriers, compared to the others.

20. At the level of vehicles, the widest distribution of crash probabilities are for Non-Illinois intrastate vehicles. Illinois interstate and Illinois intrastate vehicles have about the equal spread of crash probability.

Chapter 8

Recommendations of Study

This chapter lists the recommendations which will enhance the motor carrier and vehicle safety monitoring process. These recommendations are based on the work conducted as a part of the study. The recommendations from the study are divided into two categories: those resulting from the database evaluation and linking efforts and those resulting from the data of the data. These are given below, in Section 8.1 and Chapter 8.2 respectively.

8.1 Need for Improvements in Database Development Process

The following are the major recommendations of the study:

1. Much needs to be done to enhance the commercial vehicle data reporting and evaluation process in the United States. Currently, the data are decentralized, with crashes and inspections of intrastate carriers remaining with state-level entities and with subsets of the data on interstate carriers reported to federal databases. Further, states are lagging behind in the reporting of crash and inspection data to the Office of Motor Carriers MCMIS. The time lag between the occurrence of crashes and inspections and the entry of these data into an electronic database is far too long. In addition, data on crashes at the state level may not be complete because very often, the reporting of data from one jurisdiction within a state to the state DOT may lagging well behind. Needless to say, all this causes confusion and an extremely long and arduous process of contacting many different agencies, with various different data policies and data dissemination schedules, for even basic policy analysis of these data. Following are the types of activities that should be explored further to assist with this concern that arises from the study:

   (a) Expedite the process of updating databases: It is recommended that current Intelligent Transportation System (ITS) technologies be thoroughly investigated to make, as much as

possible, the entire process of updating inspection records and crash records, as paperless as possible. For example, an ITS may be deployed to allow state police inspectors to enter data directly, using laptop computers, into a centralized database of inspection records. Vehicle and driver-related identifiers may be "scannable", reducing the risk of inputting errors. Similarly, police crash report forms may be scanned, thus converting data directly from paper form to an electronic form. These technologies have been tested in other fields and stand to substantially expedite the current process of coding data manually from paper to a computerized version.

(b) Expedite and ease the process of data dissemination: The data that are entered by field operators, along with older data, may be housed in a centralized site. This site may be accessed by individuals with the requisite authority for both operational (to assist, for example, in the identification and prioritization of CMVs to inspect) as well as to researchers who would have the opportunity to work with much more current data. Further, all the databases used in this study, with other relevant data, may be kept in this centralized site, substantially cutting down the tremendous time and dollar cost of collecting data from the many different sources that now have to be contacted.

2. The data on carriers should be updated more frequently. Currently, using the Compliance Review process, the safety history of about 8,000 individual motor carriers were updated in 1996. In 1998, there were about 425,000 active interstate commercial motor carriers in the United States. However, data on intrastate carriers are not available and again, limited data available at the state level has to be obtained. Recently, a proposal was made to update every record once in every two years by mailing the MCS-150 form to carriers. It has also been suggested that firms be allowed to update the MCS-150 information using the internet. Further, intrastate carriers should also be required to submit the data necessary for the MCS-150. These possibilities must be investigated, if one needs to penalize unsafe carriers.

3. Various definitional differences exist among the different databases in terms of what constitutes a truck and what constitutes a certain type of carrier. There needs to be a strategy for the different data-gathering organizations to decide on a commonly accepted definition that meet all or most safety monitoring standards.

4. Much needs to be done in the area of exposure measures. Following are some recommendations that can improve the process of obtaining information on miles driven by trucks:

   (a) The International Registration Plan (IRP) data must be made available to researchers. This data was not received on time from Illinois interstate carriers and therefore, had to depend on the sources available. This data is retained by the Illinois Fuel Tax Bureau. As discussed earlier, an interstate carrier whose jurisdiction is a member of IRP has to file an application for apportioned registration with its base state or province. The base jurisdiction collects the license registration fee and distributes it to other jurisdictions based on the percentage of miles driven in each jurisdiction. The IRP application form requires the carrier to indicate fleet size and the number of miles traveled in each state. Because it is mandatory and is audited, this is a very reliable source of information, although, as discussed in Chapter 4, only on heavy interstate trucks. Further, the public portion of this data is typically aggregated to all carriers in a state for a year. If this data

can be released at a disaggregate to researchers, it would substantially improve exposure estimates used in carrier-level analysis. There are some plans that are currently under way in Oak Ridge National Laboratories to make this data available via the internet, but this process is in the beginning stages only and needs to be expedited.

(b) The MCS-150, with more frequent surveys, will also allow carriers to update their fleet mileage. Because this is a universal system of interstate carriers (although the process needs to extent to intrastate carriers), the data will be very useful in tracking crash rates of motor carriers.

(c) The 1997 Vehicle Inventory and Use Survey (VIUS, the new name for the TIUS) microdata for Illinois will be released by the Bureau of Census shortly. The estimates of mileage for interstate and intrastate trucks that have been developed in this research needs to be updated, using this more recent data source.

8.2 Policy and Operating Recommendation

Following are the major operational and policy recommendations that emerge from this study:

1. This study found that truck crash rates in Illinois are similar to the national trends during the study period of 1993 to 1996. Of almost 726,000 trucks inspected between 1993 and 1997 in Illinois, roughly 2.52% are involved in crashes within a year from the time of inspection. Although this appears to be a small number, given the fact that crashes are extremely rare events, much can be done with using the inspection process to get vehicles with high probabilities of crashes stringently inspected and appropriate corrective measures deployed.

2. A much greater percent of the trucks which are found to have a high count of violations are likely to be involved in crashes. Of all the vehicles that incurred 12 or more violations, almost 58% were vehicles belonging to Illinois interstate carriers, 22% to Illinois intrastate carriers, 18% to Non-Illinois interstate carriers and 2% to Non-Illinois interstate carriers. Pulling these bad vehicles out from the vehicle stream and allowing them back on the road only after the vehicle is appropriately attended to can go a long way to avoiding crashes. Strict monitoring needs to be done of these trucks in terms of the corrective actions taken by the owners and the drivers.

3. Vehicles that were subject to more stringent inspection standards are more likely to be uninvolved in crashes than those subjected to less stringent standards. This points to the positive impact of the higher levels of the inspection process in lowering crashes. More Level I inspections should be performed, which calls for the need for increased resources on inspection activity.

4. The study also found that intrastate vehicles are less likely to be inspected on a per mile basis than interstate trucks. This is due to the fact that inspections tend to occur in weight stations and other sites located near expressways; a number of intrastate vehicles, since they

operate in local and urban jurisdictions, can bypass those sites. In fact, in the five years of inspection data analyzed, about 54% of the vehicle units (power unit and trailer) inspected are Non-Illinois interstate. Appropriate inspection sites must be identified within urban areas where inspections can be conducted without severely disrupting the normal flow of vehicles.

5. Drivers of Non-Illinois interstate CMVs incurred the greatest Driver Out-Of-Service rates. This rate also remained about the same over the 5 years. This is probably related to violation of the hours of service regulations imposed on drivers. Interstate drivers drive long distances. Very often, there are no rest stations with easy proximity of the freeway for large interstate trucks to pull into, in order to satisfy hours of service regulations. Driver fatigue is a factor that can be extremely hazardous to driving. There is a clearly a need for drivers to have access to an information dissemination system that provides the location of access routes to rest stations.

6. Of all CMVs that were inspected in Illinois, many were involved in crashes within a year's time window from the inspection, in Illinois and in other states. Of all the vehicles that were subsequently involved in crashes, about 13% were vehicles belonging to Illinois interstate carriers, 35% to Illinois intrastate carriers, 47.2% all the Non-Illinois interstate carriers and about 5% to intrastate carriers domiciled outside Illinois. Roughly 1.67% of the trucks belonging to interstate carriers which incurred 0 violations during inspections are involved in crashes within a year of the inspection. But about 4% of the intrastate carrier vehicles which incurred 0 violations are involved in crashes within a 1 year time period after the inspection. There needs to be increased collaboration among states to share intrastate carrier and vehicle inspection/crash data, so that the crash performance of inspected vehicles can be appropriately monitored. Since the MCMIS only includes data on vehicles belonging to interstate carriers, a large part of the picture is missing from truck safety monitoring analysis.

7. About 2% of interstate vehicles and 4% of intrastate vehicles with no violations are involved in crashes within a year of the inspection. The risk factors associated with these trucks need to be analyzed in greater detail with micro data on the events surrounding the crashes, the properties of the carrier and other factors that may give a better understanding of what non-vehicle or non-driver related factors led to the involvement of the vehicle in the crash.

8. In this study, miles driven by the class of carriers to [defined by state of domicile and jurisdiction of operation] which the vehicle belongs to account for exposure measures has been used. This is clearly a limitation, although there is perhaps no better alternative at this point, given the fact that updated mileage of all carrier are not available. There are differences in crashes, when holding miles driven for the class constant. For both types of carriers [interstate and intrastate] there is an increase in the median probability of crash [as determined by a statistical model] with the vehicle class mileage.

   A more important issue that emerges is, where were those miles driven. The risk inducing by driving at high speed in heavy traffic, for example, may be quite different from driving in uncongested roads with low traffic. One would expect that many intrastate and local CMVs drive on congested urban streets where the risk for crashes are higher. Hence, it may be argued, the crash rate that is appropriate is the number of crashes on facility type f by miles driven in facility type f. However, in order to estimate the denominator of such a rate, the matter becomes more complex than before.

From the HPMS, IDOT is able to estimate annual miles driven by trucks of different classes on 12 different types of roadways. These are given below in column A of Table 8.1. The estimates are given for each of eight different vehicle classes. These estimates need to be broken down by miles driven by interstate and intrastate trucks on each type of facility. The last column in the table gives the type of facilities for which estimates may be developed in order to be consistent with all other databases where the number of crashes are available.

Table 8.1: **Facility designations in IDOT's Annual Mileage estimate scheme, IDOT Crash Files and that considered in the current study.**

A IDOT HPMS Facility Type	B Crash File Facility Type	C Facility Type Considered in Study
Interstate-rural	Rural-Unmarked State Highway	Urban-Controlled Access Highway
Interstate-urban	Rural-Controlled Access Highway	Urban-other
Freeway-urban	Rural-Other Marked State Highway	Rural-Controlled Access Highway
Principal Arterial-Rural	Rural-Country/Local Roads	Urban-other
Principal Arterial-Urban	Rural-Toll Roads	
Minor Arterial-Rural	Urban-Controlled Access Highway	
Minor Arterial-Urban	Urban-Other Marked State Highway	
Major Collector-Rural	Urban-Unmarked State Highway	
Minor Collector-Rural	Urban-City Streets	
Collector-Urban	Urban-Toll Roads	
Local-Rural		
Local-Urban		

Chapter 9

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Appendix A

Classification of Trucks

The Motor Vehicle Manufacturers Association classifies trucks by eight weight categories. Basically, trucks are divided in five size class categories that are further divided in eight Gross Vehicle Weight categories: Heavy-heavy (over 33,000 lbs.), Heavy (26,000 - 33,000 lbs.), Light-Heavy (26,000 - 14,000 lbs.), Medium (14,000 - 6,000 lbs.), and Light (under 6,000 lbs.).

The numerous commercial motor vehicle safety databases considered in this study use different definitions of "trucks". What may classify as a truck in one database may not necessarily be considered as a truck in another database. In some cases, it is possible to find out the differences in the definitions; in those cases, care was taken in this study to make the data compatible, especially when linked data (data obtained by linking different databases) were used for the analysis. But in many cases, it is extremely difficult to point out and take definitional differences into account.

Appendix B

Commerical Motor Vehicle Regulations

B.1 Federal and State of Illinois CMV Regulations

Federal Motor Carrier Safety Regulations and Regulatory Guidance is a regulatory code used nationwide to assure that safety standards are met by Commercial Motor Vehicles utilizing the U.S. road network. The 49 Code of Federal Regulations is a fairly comprehensive regulatory document that deals with most Commercial Motor Vehicle safety issues such as Commercial Driver's License Standards, Inspections, repairs and maintenance, hours of service of drivers. A listing of these regulations is given in Table B.1.

Part 396 of the Federal Motor Carrier Safety Regulations is the section related to the Inspection, Repair and Maintenance of Commercial Motor Carriers.

Part 396 is subdivided as follows:

396.1 Scope.

396.3 Inspection, repair, and maintenance.

395.5 Lubrication.

396.7 Unsafe operations forbidden.

396.9 Inspection of motor vehicles in operation.

396.11 Driver vehicle inspection report(s).

Table B.1: **Listing of Selected Code 49 of Federal Regulations.**

Code 49 of Federal Regulations
• Procedures for Transportation Workplace Drug and Alcohol Testing Programs
• Organization and Delegation of Powers and Duties of the Federal Highway Administration
• Compliance with Interstate Motor Carrier Noise Emission Standards
• Commercial Motor Carrier Safety Assistance Program
• Compatibility of State Laws and Regulations Affecting Interstate Motor Carrier Operations Waivers, Exemptions, and Pilot Programs
• Controlled Substances and Alcohol Use and Testing
• Commercial Driver's License Standards; Requirements and Penalties
• State Compliance With Commercial Driver's License Program
• Safety Fitness Procedures
• Rules of Practice for Motor Carrier Safety and Hazardous Materials Proceedings
• Minimum Levels of Financial Responsibility for Motor Carriers
• Cooperative Agreements with States
• Rulemaking Procedures - Federal Motor Carrier Safety Regulations
• Federal Motor Carrier Safety Regulations; General
• Qualifications of Drivers
• Driving of Commercial Motor Vehicles
• Parts and Accessories Necessary for Safe Operation
• Hours of Service of Drivers
• Inspection, Repair, and Maintenance
• Transportation of Hazardous Materials; Driving and Parking Rules
• Transportation of Migrant Workers
• Employee Safety and Health Standards

396.13 Driver inspection.

396.15 Driveaway-towaway operations, and inspections.

396.17 Periodic inspection.

396.19 Inspector qualifications.

396.21 Periodic inspection and recordkeeping requirements.

396.23 Equivalent to periodic inspection.

396.25 Qualifications of brake inspectors.

396.1 Scope

Every motor carrier, its officers, drivers, agents, representatives, and employees directly concerned with inspection or maintenance of motor vehicles shall comply and be conversant with the rules or this part.

396.3 Inspection, repair, and maintenance

(a) General

This section indicates clearly that every motor carrier have to systematically inspect, repair and maintain all commerical motor vehicles subject to its control.

All motor carriers will be responsible for having all parts and accessories in safe and proper operating conditions at all times.

Subsection (a) (2) points that pushout windows, emergency doors, and emergency door marking lights in buses shall be inspected at least every 90 days.

(b) Required Records

The following records are required for vehicles controlled for 30 consecutive days or more:

1. An identification of the vehicle including:
    - company number
    - if so marked, serial number
    - year
    - tire size

If the vehicle is not owned by the motor carrier, the record shall identify the name of the person furnishing the vehicle.

2. A means to indicate the nature and due date of the various inspection and maintenance operations to be performed.

3. A record of inspection, repairs, and maintenance indicating the their date and nature.

4. A record of tests conducted on pushout windows, emergency doors, and emergency door marking lights on buses.

(c) Record Retention

The records required by this section have to be retained where the vehicle is housed or maintained for a period of one year and for six months after the motor vehicle leaves the motor carrier's control.

395.6 Lubrication

This subsection indicates that motor carriers are responsible for having all the vehicles properly lubricated for operations.

396.7 Unsafe operations forbidden

A motor vehicle that when operated would be in a condition to likely cause an accident or a breakdown will not be allowed circulate. Exemption: Any motor vehicle traveling in an unsafe condition on the highway may continue riding only to the nearest place where repairs can safely be affected.

396.9 Inspection of motor vehicles in operation

Subsection (a) defines the authorized personnel to perform inspections.

To record the results of motor vehicle inspections authorized FHWA personnel will use the *Driver-Equipment Compliance Check.*

Authorized personnel shall declare and mark "out of service" any motor vehicle which by reason of its mechanical condition or loading would likely cause an accident or a breakdown. An "Out-of-Service Vehicle" sticker would be used to mark vehicles "Out-Of-Service".

No motor carrier should allow anybody to operate a vehicle declared "Out-of-Service" until all the repairs required by the OOS notice have been satisfactorily completed. Likewise, nobody can remove the "Out of Service" sticker until all repairs required have been taken care of.

Motor carrier disposition

The driver or any motor vehicle receiving an inspection report has to deliver it to the motor carrier

operating the vehicle upon his/her arrival at the next terminal. If the vehicle is not scheduled to arrive in within 24 hours, then the report can be mailed.

Motor carriers must examine the reports, then violations or defects must be immediately corrected.

Within 15 days following the date of inspection, the motor carrier must accomplish two things:

1. Certify that all violations noted have been corrected by completing the "Signature or Carrier Official, Title, and Date Signed" portions of the form;

   and

2. Return the completed roadside inspection form to the issuing agency at the address indicated on the form and retain a copy at the site where the vehicle is housed for 12 months from the date of inspection.

396.11 Driver vehicle inspection report(s)

Every motor carrier shall requires its drivers to prepare a report at the completion of each day's work on each vehicle operated.

The report should include the following parts and accessories:

Service brakes including trailer brake connections

- Parking (hand) brake
- Steering mechanism
- Lighting devices and reflectors
- Tires
- Horn
- Windshield wipers
- Rear vision mirrors
- Coupling devices
- Wheels and rims
- Emergency equipment

In all instances the driver shall sign the vehicle report. On two-driver operations, only one driver needs to sign the report, provided both drivers agree on the report outcome. If a driver operates more than one vehicle during the day, a report has to be prepared for each vehicle operated.

Prior to operating a motor vehicle, motor carriers or their agents have to repair any of the items listed on the vehicle inspection report that would be likely to affect the safety of the operation of the vehicle. Motor carriers or their agents are to certify the defects or deficiencies, if any, have been corrected or state that correction is unnecessary before the vehicle is dispatched again.

Motor carriers will retain the original copy of each vehicle report and certification of repairs for at least three months from the date the report was prepared. A legible copy of the last vehicle report, certified if necessary, must be carried on the vehicle.

396.13 Driver inspection

Before driving a vehicle the driver will:

1. Feel satisfied that the motor vehicle is in safe operating condition.
2. Review the last vehicle report required to be carried on the vehicle
3. Sign the report, only if defects of deficiencies were noted by the previous driver, to acknowledge that the driver has reviewed it and that there is a certification that the required repairs have been performed.

396.15 Driveaway-towaway operations, and inspections

This are guidelines specific for driveaway-towaway operation of motor carriers.

396.17 Periodic inspection

Every commercial vehicle has to be inspected as required by this section. The inspection has to include the minimum standards set forth in Appendix G of subchapter 396.

A motor carrier will not use a commercial motor vehicle unless each component identified in Appendix G has passed an inspection in accordance with the terms of this section at least once during the preceding 12 months and documentation of such inspection is on the vehicle.

This section clearly States that a motor carrier cannot use a commercial motor vehicle unless each component identified in Appendix G has passed an inspection in accordance with the terms of this section at least once during the preceding 12 months and documentation of such inspection is on the vehicle. The documentation may be an inspection report prepared in accordance with paragraph 396.21 (a), or other forms of documentation, based on the inspection report (e.g., sticker or decal), which certifies that the vehicle has passed an: inspection in' accordance- with paragraph 396.17.

396.19 Inspector qualifications

This section has the guidelines that personnel must have in order to perform motor vehicle inspections. The paragraph states the training and experience required by State, Provincial or Federal Government inspectors.

396.21 Periodic inspections and record keeping requirements

Whenever an inspection takes place, the record must have the following information:

1. Identification of the individual performing the inspection
2. Identification of the motor carrier operating the vehicle
3. Date of inspection
4. Identification of the vehicle being inspected
5. Vehicle components inspected and description of the results of the inspection
6. The record must certify the accuracy and completeness of the inspection

396.23 Equivalent to periodic inspection

If a commercial motor vehicle is subject to a mandatory State inspection program which is determined by the Administrator to be effective as the guidelines set forth in 396.17, the motor carrier would have to met the requirement of 396.17. Commercial motor vehicle inspections may be conducted by State personnel, at State authorized commercial facilities, or by the motor carrier under the auspices of a State authorized self-inspection program.

396.25 Qualifications of brake inspectors

This subsection defines who are and can be qualified brake inspectors, also gives a detailed listing of training and experience required to performed this duty.

"For purposes of this section, 'brake inspector' means any employee of a motor carrier who is responsible for ensuring all brake inspections, maintenance, service, or repairs to any commercial motor vehicle, subject to the motor carrier's control, meet the applicable Federal standards."

The Illinois Motor Carrier Safety Regulations

The Illinois Motor Carrier Safety Regulations on November 18, 1996 has the following considerations regarding part 396(Inspection, Repair and Maintenance):

In general takes the general guidelines from the Federal Motor Carrier Safety Regulation FMCSR.

The following interpretations of, additions to and deletions from 49 CFR 396 are part of the Illinois version for Motor Carrier Safety Regulations:

1. Section 396.9 is deleted and not incorporated. (Inspection of motor vehicles in operation). Instead, the Illinois Motor Carrier Safety Regulation incorporates section 396.2010 that deals exactly with the same issues.

   The Illinois Code states that the Illinois State Police is authorized to perform commercial vehicle inspections. Then, it identifies the criteria to declare a vehicle "Out-Of-Service" As in the federal standards, a sticker will be placed on a vehicle that does not meet "North American Uniform Out-of-Service criteria." Likewise, nobody would be able to remove the sticker until all repairs required by the "out-of-service notice" have been taken care of.

   Also, just like federal standards, the Illinois Code requires that the driver of any motor vehicle receiving an inspection report must deliver it to the next facility or terminal, or mail it to its motor carrier within 24 hours. Within 15 days from the date of the inspection, the motor carrier must certify that all violations noted in the report have been corrected. Also, a completed Illinois Commercial Driver/Vehicle Inspection Report (ISP 5-238) has to be mailed to the Illinois State Police. The motor carrier will keep a copy of the ISP 5-238 at the main office or where the vehicles is housed for at least 12 months from the date of inspection.

2. Section 396.11 which indicates that every commercial vehicle driver has to prepare a detailed daily report of the vehicle is eliminated:

   "SECTION 396.11 SHALL NOT APPLY TO THE OPERATOR OF A COMMERICAL VEHICLE USED IN INTRASTATE COMMERCE."

3. Paragraphs (b) and (c) of section 396.13 (Driver Inspection) are eliminated from the Illinois Safety Regulations. The driver is required to only be satisfied that the motor vehicle is in safe operating condition. The eliminated paragraphs read as follows:

   b) Review the last vehicle inspection report required to be carried on the power unit.

   c) Sign the report only if defects or deficiencies were noted by the driver who prepared the report, to acknowledge that the driver has reviewed it and that there is a certification that the required repairs have been performed. The signature requirement does not apply to listed defects on a towed unit which is no longer part of the vehicle combination.

4. Any commercial motor vehicle used in intrastate commerce that is inspected semi-annually in accordance to the section 13-109 of the Illinois Vehicle Code will be considered in compliance with the periodic inspection procedures required by the Federal standards stated in paragraph 396.17.

Table B.2: **Main Differences Between Federal and Illinois Section 396 Safety Regulations**

Section	Federal Regulations	State of Illinois Regulations	Main Changes
396.1	Scope	Same	
396.3	Inspection Repair and maintenance	Same	
396.5	Lubrication	Same	
396.7	Unsafe operations forbidden	Same	
396.9	Inspection of motor vehicles in operations	Deleted	Replaced by Illinois Section 396.2010 which authorizes the Illinois State Police to perform inspections
396.11	Driver vehicle inspection report(s)	Same	Completely eliminated driver's daily inspection and reporting
396.13	Driver inspection	Partially eliminated	As far as the driver is satisfied with the Vehicle safe operation, there is no need for him to review previous inspection reports
396.15	Driveaway-toaway operations and inspections	Same	
396.17	Periodic inspections	Replced	The semi-annual inspection in accordance with to Section 13-109 of the Illinois Vehicle Code will satisfy the federal periodic inspection requirement
396.19	Inspector qualifications	Same	
396.21	Periodic inspection recordkeeping requirements	Same	
396.23	Equivalent to periodic inspections	Same	
396.25	Qualifications of brake inspectors.	Same	

Appendix C

Description of Databases

As discussed in Chapter 2, there are two categories of data that may be used for motor carrier and vehicle safety. These are safety databases and exposure-related databases. This technical appendix provides a description of these databases.

C.1 Safety Databases

The data on crashes as well as inspection violations should be examine in order to obtain a true picture of the safety history of classes of motor carriers and CMVs. Below, are the some readily-available databases that would allow an analysis of such issues. In Section C.1.1, we have discussed relevant databases available in the State of Illinois on motor carrier safety. In Section C.1.2, a description of the national-level databases are given.

C.1.1 State Motor Carrier Safety Databases

The State of Illinois databases that were used to analyze CMV safety trends are the Illinois Department of Transportation's (IDOT) Crash Files and the Illinois State Police's (ISP) Commercial Motor Vehicle Inspection Files.

IDOT Crash Files

The IDOT Crash Files contain detailed information on all the crashes involving all vehicles that occurred within the State of Illinois. Crashes that involved trucks are supplemented with additional data on carriers and other variables. Further, information on the characteristics of the fatalities or

injuries are available from the occupant file. Thus, the range of files available in analyzing CMV crashes from the IDOT crash system has three component files-commercial vehicle data, vehicle file and occupant data.

The commercial vehicle data file contains information related to accident location, carrier information to which the CMV involved in a crash belongs (carrier name and address, USDOT number, ICC number, Illinois DOT number, carrier state and city), sequence of events in crash, hazardous material information, vehicle information etc. However, most of this information was not available for this study (the reasons will be given in Chapter 5). The vehicle data file contains information about accident severity, accident rate, case number, collision type, number of CMV involved, driver information, sequence of events, number of occupants, vehicle identification number. The occupant data file contains information about the occupants personal data such as age, sex, date of birth and also the occupant's location in vehicle at the time of crash, injury severity and the case number.

All the three component files of the IDOT crash files can be linked using a common case number that is present in all the three data sets. The IDOT crash data sets are basically developed from the information obtained from police reports generated from the accidents, and a detailed data set is developed for all the CMV that are involved in the crash within Illinois.

ISP Inspection Files

Currently, there are two types of inspections that the interstate and intrastate CMV's go through. Interstate CMV's are required to be safety inspected on an annual basis while the intrastate CMV's are required to do so on a semi-annual basis. Apart from these, both interstate and intrastate CMV's are subjected to random roadside inspections under the federally mandated Motor Carrier Safety Inspection Program (MCSAP). In Illinois the roadside inspections program is administered by the Illinois State Police (ISP). They maintain an extensive record of the various levels of inspection carried out on different types of CMV's. This dataset is described in Chapter 4. The ISP files contain a complete record of different types of violations, both safety and otherwise, that are detected during the inspection as well as the Out-of-Service (OOS) violations. The inspection files contain information on interstate as well as intrastate CMV's that are inspected. The state police inspection file reports are uploaded to the MCMIS through a state-level microcomputer based system called the SAFETYNET.

The Illinois State Police (ISP) collect data from each roadside inspection into a series of separate data files that are collectively known as the State police inspection files. There are seven major components constituting the state police inspection file. These are briefly described below and summarized in Table C.1. There is a large amount of data available in these files and all these files can be linked together with a common inspection number.

The inspection file is the universal file containing information on the actual attributes of the inspection that a CMV was subjected to as well as the results of the inspection. The inspection files contains information about the inspection number (one unique record for each inspection in

Table C.1: **Description of Illinois State Police Inspection Files.**

File Title	Description
VEHICLE file	Contains detailed description of vehicles involved in inspection
CARRIER file	Contains information on motor carriers to which the inspected vehicle belongs
INSPECT file	Contains results of the inspection including the type of inspection and OOS violations
HAZMAT file	COntains information on inspection pertaining to CMV's carrying hazardous material. Results of this inspection are also a part of the INSPECT file
LICENSE file	Contains information about the endorsement of the driver
VERIFY file	The VERIFY contains information about the tickler
hline VIOFILE	Contains information on violations written against vehicle or driver
ACCIDENT file	Contains the accident number if the vehicle was inspected after accident

the inspection file), the date of inspection, inspection year, begin time, end time, inspection type, inspection results, location of inspection, carrier ID number to which the vehicle belongs, personal information of the driver, shipper information and dates on which the record was added or modified.

The vehicle file contains information about the CMV that was inspected. The relationship to the inspection file to the vehicle file is one to many relationships. For every inspect file record there can be multiple vehicle file records. The Vehicle file contain data on the inspection number, vehicle type, vehicle make, vehicle year, carrier fleet ID number, license plate/registration number, vehicle identification number and dates the record was added or modified.

The carrier file contains information about the carrier to which an inspected CMV belongs. The information in the file includes data on carriers Interstate Commerce Commission (ICC) number, USDOT number, carrier name, location, country, whether the carrier is classified as an interstate or intrastate carrier. The Carrier file is associated with a common data variable in the inspect file. The Carrier file is updated quarterly, and the information on the date the carrier name was added or modified is also available in the Carrier file.

The HAZMAT file contains information on CMV carrying hazardous materials. The database contains information on the inspection number, commodity ID, hazardous material class code, waste indicator, quantity, degree of danger code, date and time the record was added or changed. The HAZMAT file has one to one relationships with the inspect file, for each record in the HAZMAT file with an inspection number there is a unique record in the inspection file with the same inspection number.

The License file contains detail information of the driver. The data contains information on the inspection number, driver's commercial driver's license (CDL) endorsement to drive a particular type of CMV, dates and times the record was added or modified. The inspection number in this file is unique and it has a one to one relationship with the inspection file. As in earlier cases the

inspection number can be used to link License file with the Inspection file.

The violation file contains information on the violations that the inspector might have written against the driver or the vehicle during inspection. The information in this data includes inspection number; action taken when the violation was detected, document type of the violation, date and times the record was added or modified. The violation may contain up to four records (or four violations) that relate to the same inspection record in the inspection file. The inspection number as in other cases is used to link up the violation file data with the inspection file.

The accident file contains information on the accident number if the vehicle was inspected after an accident. It also contains the dates and times the record was added or changed. As in the other cases the accident file has an inspection number which can be used to link this file to the inspection file. For each accident file record, there is one inspection file record but not vice-versa.

C.1.2 National Safety Databases

The national sources of data on motor carrier safety reviewed here are the MCMIS databases maintained by the Office of Motor Carrier (OMC) of the Federal Highway Administration (FHWA), the Fatal Accident Reporting System (FARS) and the General Estimates System (GES) maintained by the National Highway Transportation Safety Administration (NHSTA) and the Trucks Involved in Fatal Accident (TIFA) produced by the University of Michigan.

Office of Motor Carrier Databases

The Office of Motor Carriers (OMC) is the office within the Federal Highway Administration (FHWA) of the Department of Transportation (DOT) responsible for monitoring and developing safety standards for commercial motor vehicles operating in the United States. The Motor Carrier Management Information System (MCMIS), which is a computerized system maintained by OMC maintains three types of data: on crashes, on inspections and on characteristics of motor carriers (firms).

A subset of the state-level crash and inspection files (from all states but similar to the ones described for Illinois in Section C.1.1) are uploaded to MCMIS using a PC-based computer system called SAFETYNET. In this study, these national level files have been used as well. The reason being interest in constructing safety histories of CMVs, that are based on all crash or inspection violations that were incurred by that CMV. In order to do this, a search for records of that CMV's crash or inspection violation is carried out. A CMV that was inspected in Illinois may subsequently have been involved in a crash outside Illinois. Similarly, a CMV that was involved in a crash in Illinois may have had prior inspection violation in a state outside Illinois. These subsequent crash or prior inspection violation activities that would be available only by considering data from other states and the OMC databases serve as central repository of data from all states.

(A) FHWA OMC Crash Files

The OMC crash file contains data from the state police crash reports involving drivers and vehicles of motor carriers operating in the United States. Each report contains about 80 data elements pertaining to the motor carrier, driver, vehicles, fatalities, injuries and circumstances of a crash. This data is collected by the OMC through a Federal Highway Administration's (FHWA) Motor Carrier Safety Assistance Program (MCSAP) which is a grant program administered by OMC. Under this program, with the cooperation of states, the OMC has implemented a crash reporting system based on state police crash reports that are electronically transmitted from the states to the FHWA. The latest phase of this implementation is based on uniform crash data elements developed through the National Governors Association (NGA). The data collected are entered into a microcomputer based system called SAFETYNET which allows states to do analysis on all motor carriers in the state and to transmit this data to the MCMIS.

The MCMIS Crash File contains data on National Governor's Association (NGA)-reportable crashes. These crashes include trucks (defined as a vehicle designed, used or maintained primarily for carrying property that has at least two axles and six tires) or bus (a vehicle with seats for at least sixteen people, including the driver). The crash must result in at least one fatality or at least one injury where the person injured is taken to a medical facility for immediate medical attention or one vehicle having been towed away from the scene as a result of disabling damage suffered in the crash.

Not all crashes which are available in the state (either with the department of transportation or the state police) are in the MCMIS Crash File. In fact, only a small subset of the CMV crashes in the IDOT Crash Files are in the MCMIS Crash File. But even when compared with another national crash database [the General Estimates System (GES), maintained by the National Highway Transportation Safety Administration (NHTSA)], the crash numbers reported from states to MCMIS appear to be quite low. For example, for 1997, states reported 96,585 trucks involved in crashes through SAFETYNET to the MCMIS Crash File, whereas according to GES estimates, about 444,000 large trucks were involved in crashes (OMC, 1998).

The MCMIS Crash file may contain multiple records for a crash. Separate reports are present for each CMV involved in a crash. Since the research focuses only on trucks we will ultimately exclude the information related to crashes involving buses. This however does not mean that in a crash involving a bus and a truck the information regarding the truck would be ignored. The variables from this dataset that are used in this study are described in the next chapter.

Although this data is quite comprehensive it does not allow to figure out the exact cause of the crash. Some other problems related to the OMC crash database have been identified in a recent General Accounting Office (GAO) report to the subcommittee on transportation and related agencies, committee on appropriations, house of representatives. These problems relate to the identification of high risk carriers for on-site compliance reviews. To identify high risk carriers the OMC uses a 'safety status' measurement system known as SafeStat. SafetStat relies heavily on data from MCMIS to rank motor carriers on the basis of four factors- crashes, driver's performance, vehicle's mechanical condition and safety management. The first factor i.e. crashes is given twice the weight of other

factors because carriers whose vehicles have been involved in crashes are considered more likely to be involved in crashes in future. Carrier's that are ranked in worst 25% for three or more factors or for the first factor plus one other factor are targeted for compliance reviews.

However, it is mentioned that SafeStat's ability to accurately target highrisk carriers is limited because state officials do not report a large number of crashes involving heavy trucks to the MCMIS. For instance, in 1997, OMC estimated that states did not report 38% of all reportable crashes and 30% of the fatal crashes involving large trucks. Furthermore, 10 states reported fewer than 50% of the fatal crashes occurring within their borders, including four states that reported fewer than 10%. Although the GAO report focuses on the inability of SafeStat to detect high risk carriers because of insufficient crash data our research would also be affected and we have to work within this adversity and data limitation.

(B) FHWA OMC Inspection File

The OMC Inspection file contains data from state police inspection reports involving drivers and vehicles of motor carriers operating in United States. Each report contains about 80 data elements pertaining to the motor carrier, driver, vehicles and circumstances of an inspection. As in the case of OMC crash file the data collected at the state level is electronically transmitted to FHWA under the OMC-administered MCSAP program. A uniform set of data inspection elements has been developed through the National Governors Association (NGA). The data is transmitted from the states to the MCMIS through the SAFETYNET environment. The inspection file may contain multiple records for each inspection that can be distinguished by the format of the report number.

The OMC inspection files have four component files unlike the state police inspection files which have eight component files. The four files provide information on the uniform inspection data elements developed by the NGA. These four files are- inspection, inspection/violation, inspection/unit, and inspection/shipper.

The inspection file provides information about the inspection date, duration of inspection, USDOT number of the carrier to which the CMV belongs, inspection level, OOS defects verification (whether repaired at scene, towed away or restricted service), hazardous material, carrier information (carrier name, address and state, ICC number, whether interstate or intrastate), driver information, total violations, OOS inspections, driver violations, vehicle violations, hazardous material violations, alcohol and drug check, size-weight enforcements and dates on which records were added or changed.

The inspection/violation file contains information about the violation unit (driver or/and vehicle unit), whether the violation resulted in driver or vehicle Out-Of-Service, violation category (driver, vehicle, hazardous material or other). The information contained under violation category gives the exact (as determined by the relevant authorities) cause of the violation.

The inspection/unit file describes the vehicle unit type (truck tractor, semi trailer, straight truck, full trailer, bus or dolly converter etc), vehicle unit make, company that made the unit, vehicle unit

license, unit state and Vehicle Identification Number (VIN) for each vehicle unit.

The inspection/shipper file provides the shipper name and address, shipper city and state, shipper census number and violation sequence number.

All the four component files of an OMC inspection file dataset can be linked using a common report number built into each of these individual databases. These database this very large; the size of the total dataset that was made available to us is about — gigabytes.

(C) FHWA OMC Carrier File

The MCMIS data file contains records for approximately 470,000 active entities, i.e., motor carriers, hazardous materials shippers, both a carrier and a shipper, or registrants (entities who register vehicles but are not carriers). In order to identify each entity, MCMIS assigns a unique number to each entity record. This number is also the number supplied to an entity as their USDOT number.

The OMC Carrier file gives a detailed description of the status of the carrier, whether the entity is in active state or inactive state. An Active status means the entity is currently in business and subject to Federal Motor Carrier Safety Regulations (FMCSR), Hazardous Materials Regulations (HMR), or is an intrastate non hazardous material carrier issued a USDOT number by selected States. An Inactive status means the entity is no longer in business or is no longer subject to the FMCSR or HMR.

The Entity type refers to the type of operation in which the entity is engaged. It identifies the entity as a carrier, hazardous materials shipper, both a carrier and a shipper, or a registrant. All these Commercial Motor Vehicles are assigned a number by the MCMIS to a census record known as the USDOT Number. Each entity should have only one active census number. The census numbers are issued sequentially as entities are added to the system. Also a legal name of the entity, the trade name and a Federal tax identification number are registered in the carrier file. Additional carrier characteristics include address, fleet size, annual mileage, primary commodities transported.

Fatal Accident Reporting System

The Fatal Analysis Reporting System (FARS) was developed and maintained by the National Highway Transportation Safety Administration's (NHTSA) National Center for Statistical Analysis, which is a component of NHTSA Research and Development. As the name suggests, this is a database on fatal crashes only and is regarded to be the most reliable source of data on this issue. The FARS database consists of police reports of crashes in the United States and Puerto Rico that result in at least one fatality within 30 days of the crash. The system is used to monitor accident trends in major vehicle classes (passenger cars, light trucks, medium and large trucks and motorcycles). The basic concern is about the light, medium and large trucks in our project. A large truck in

FARS is defined as a truck with a gross vehicle weight rating (GVWR) of more than 10,000 pounds. Hence, there are differences in the definitions of trucks as used by the MCMIS and FARS, but the numbers on the same types of crashes (fatal crashes) should be very close from the two sources. For example, the number of trucks involved in fatal crashes in Illinois in 1997 was 166 according to FARS and 125 according to MCMIS.

The FARS, which became operational in 1975, has obtained data from the existing documents from the different sources of the state. The main sources from which the data has been gathered are the police accident reports, Death certificates, State vehicle registration files, Medical examiner reports, State licensing files, Hospital medical reports, State highway department data, Emergency medical service reports.

The FARS database contains reports on about 60,000 fatal incidents per year that involves vehicles, and about 5,000 of these involve medium and large trucks. Police accident reports are the primary data source for FARS, supplemented by other materials necessary such as the driving licensing, vehicle registration, State roadway inventory and emergency medical service files. In addition, police officers who investigate the accidents are sometimes interviewed to get information to build up the database. The State employees perform the data collection under contract to NHTSA. A FARS file for any year is usually available about six months after the end of that calendar year. FARS has been computerized since 1975.

Since 1975 a comprehensive coding manual has been produced each year. The coding manual provides a set of data from a police accident report (PAR) to the FARS system. Each year since 1975, the set of FARS codes have changed to suit the requirements of the small changes made to the format of data collection.

FARS contains information on the vehicle, roadway, state, accident circumstances, driver, and occupants. Information on trucks is limited to vehicle configuration (single-unit trucks or truck- tractors pulling one, two, or three or more trailers); however, FARS did not report the number of trailers until 1983. Information on cargo, body style and carrier information is not included.

There are 100's FARS data elements which are coded, the specific data elements may be modified slightly each year to conform to changing user needs, vehicle characteristics and highway safety emphasis areas. FARS does not include any personal identification information such as name, social security number etc., thus maintaining complete privacy. Each analyst enters data into a local microcomputer data file, and daily updates are sent to NHTSA central computer database. Data are automatically checked when entered for acceptable range values and for consistency, enabling the analyst to make immediate corrections.

The FARS analytic references have three main sections, one for each of three principal file types. These files are the Accident, Vehicle and person files. Each of the three sections is divided in to two pieces. The first piece of a section is a cross tabulation or index for the second piece. The variables and several key words are in alphabetical order in the first column. The names of the variables are in upper case, while the key words are in lower case.

Across from the FARS variables and key words are one or more headings of the segments and corresponding page numbers, which provides information about the variable, key word or associated variables to be considered. The second section are arranged alphabetically by heading and arranged in the reverse chronological order. When appropriate notes are included in the documentation to the system, the database gets updated and the latest information is made available.

FARS data is not used in this study because the scope of crashes examined is "all crashes". However, this last phrase will be further qualified later on, because crashes that were finally analyzed are those on which data were readily available.

General Estimates System (GES)

The General Estimates System (GES) is a part of the National Accident Sampling System that began operation in 1988 and is directed by the National Center for Statistics and Analysis, NHTSA. The GES obtains its data from a nationally representative probability sample selected from the estimated 6.5 million police reported crashes that occur annually. These crashes include those which results in a fatality or injury and those involving major property damage. The GES concentrates on those crashes of greatest concern to the highway safety community and general public. GES is currently the only probability-based program that contains both fatal and nonfatal crashes of medium and heavy trucks. It uses the same definition of a truck as the FARS. The sample contains both about 45,000 police accident reports selected from 60 primary sampling units (PSUs) out of the total of about 1,200 possible PSUs in the United States.

The GES sample design involves three levels of selection. First, the sample of 60 nationally representative PSUs is selected. The data collectors make weekly, biweekly, or monthly visits to approximately 400 police agencies within the 60 geographic sites selected. Each PSU may be a city, the balance of a county containing a city, a county, or a group of counties. Second, a random sample is drawn of police jurisdictions within each selected PSU. Each PSU typically has about seven police jurisdictions. Third, police accident reports within the sampled police jurisdictions are randomly selected. GES analyst make regular visits to each selected jurisdiction to add to the list police accident reports that were not previously listed. A random sample of police accident reports is then drawn, and copies of the sampled accident reports are sent to a central contractor for coding. Trained personnel interpret and code data directly from the police accident reports onto an electronic file. During data coding, the data are checked for validity and consistency. After the data file is created, quality checks are performed on the data. In 1988, it's first year of data collection, GES captured about 2,000 to 3,000 crashes involving medium and heavy trucks.

In GES, information on truck characteristics is limited to vehicle configuration. Information on cargo body style, carrier identification, and hazardous cargo involvement is not available. GES has fewer data elements than FARS, but common data elements between the two files usually have similar definitions and levels of detail.

Trucks Involved In Fatal Accidents (TIFA)

The Trucks Involved In Fatal Accidents (TIFA) database is produced by the University of Michigan Transportation Research Institute (UMTRI). The TIFA combines data from the FARS with police accident reports and telephone interviews conducted by UMTRI research staff. The TIFA contains data on most FARS variables and has information on all medium and heavy trucks involved in fatal accidents in the continental United States. Additional data obtained during the interviews are also available in the TIFA database. As in the case of FARS, since we are interested in non-fatal crashes as well, this database is not used in this study.

C.2 Databases for Exposure Measures of Trucks

As indicated in Chapter 1, estimation of exposure measures is a critical aspect of safety statistics. While national and state level VMT estimates for trucks are readily available, most studies intend to analyze crash rates at a level of disaggregation well below the gross state and national level. This is a problem because although there are a number of databases which can provide some estimates of miles driven by trucks, the databases vary tremendously in terms of the level of spatial aggregation and aggregation over type of carrier, trucks.

In the following sections below, provides a detailed discussion of the major sources of data that are available for public use and which may be available to researchers to conduct truck safety studies. The sections discuss the Highway Performance Monitoring System (HPMS), Vehicle Inventory and Use Survey (VIUS), Commodity Flow Survey (CFS), the Office of Motor Carrier (OMC) Carrier Census File, Motor Vehicle Registration Department data and Motor Fuel Tax Department data.

C.2.1 Highway Performance Monitoring System

The Highway Performance Monitoring System (HPMS) is a nationwide inventory system that includes mileage on all public roads in the US. A primary purpose of the HPMS is to serve the data and information needs of the FHWA and Congress. The HPMS assesses the system length, use, condition, performance, and operating characteristics of the highway infrastructure. The FHWA has all the HPMS data from 1978 to the present. Individual States generally will have only their most recent few years.

Each state in the United States has a system of roads and highways which are defined as the universe of road sections. A road section is a definite part of a state road often having the same features (such as grade, number of lanes, geometry and so on). From this universe of sections, a sample of sections is selected based on certain stratification criteria. In Illinois, there are three criteria which include Annual Average Daily Traffic (AADT), functional classification of the section and the extent of urbanization (total rural, total small urban and individual urbanized areas) of the area in which

the section lies. There are approximately 3800 sample sections in Illinois (Illinois Traffic Monitoring Program, IDOT Department of Planning and Programming, 1995, page 3).

The IDOT has a large and complex traffic monitoring system from which an extensive amount of data result. Traffic counting on the sections are done on a "rotating" basis over time – once, for 48 hours, every three years. In any one year, 1/3 of the 3800 sample sections are volume counted. For certain routes (State Primary Routes), the cycle is two years. For vehicle classification, about a 100 randomly selected sections are sampled every three years for a 48-hour measurement period. Truck weighting is done at 90 randomly selected sections (30 are Interstate samples and 60 non-Interstate) in a three-year cycle, with 1/3 measured each year.

Under the current Federal Highway Administration (FHWA) recommended practice for estimating VMT, the first step is to estimate Annual Average Daily Traffic (AADT) for each section. Then the section AADT is multiplied by the section length and by stratum expansion factor. Aggregate estimates at any level or functional class (type of facility, urban-rural, seasonal and time of day) can now be derived by summing the truck VMT of the appropriate strata.

The FHWA vehicle categorization includes 13 categories, 10 of which are truck categories; there is also an eight vehicle category system that IDOT uses, which has six truck categories and finally, there is three-category, two of which are non-passenger vehicle categories.

Inaccuracies in truck VMT estimation can arise from many sources: (i) measurement/inherent equipment errors, (ii) errors stemming from factoring/adjustment procedures applied to sample data to get estimates of total truck VMT (iii) errors arising from location of equipment (iv) errors arising due to variability in traffic flow over time [over day of week or due to seasonality factors] and due to inadequate sample size in certain vehicle classes, and (v) variability in directional traffic.

C.2.2 Vehicle Inventory and Use Survey (VIUS)

The VIUS provides detailed data (at the level of trucks) on the physical and operational characteristics of a random sample of the truck population in the U.S. This data has been used in this study to obtain estimates of truck VMT incurred by interstate trucks within Illinois and Illinois intrastate trucks within Illinois. The VIUS can be used to provide estimates of AVMT on moving different classes of goods and commodities, type of operation (for-hire or private operations), type of service (truckload or less-than-truckload) and other indices that could provide a comprehensive picture of truck travel.

The VIUS has a very large sample size. The sample size for Illinois is about 2500 trucks. Roughly 154,000 vehicles were selected for the survey in 1992. Nearly 132,000 trucks are represented in the file. Estimates of population totals and annual travel from the VIUS have been compared with estimates generated by other techniques and are in general agreement. Data collection procedures and survey questions have been fairly stable for a number of surveys, so comparisons among survey years are valid.

The VIUS considers a vehicle to be a truck if it is a pickup, panel truck, minivans, sports utility vehicles, jeeps, station wagons built on a truck chassis, single unit light, single-unit heavy and truck tractors. Clearly, some of these categories of vehicles cannot be compared as trucks for this purposes. Hence, steps had to be taken to ensure that only those trucks from the TIUS sample that meet the criteria of commercial vehicle operation. Further, since the end-use of the VMT estimation would be to serve as exposure measures in safety assessment, it is pertinent that the definition of a truck should match that of the vehicle and carrier safety and inspection files. The study is interested only in those categories of trucks that participate in commercial motor vehicle activities and are registered to be used for commercial purposes. Unfortunately, the TIUS does not ask the direct question of whether or not the vehicle surveyed is registered as a commercial vehicle. Rather, it asks respondents if the target vehicle was "for-hire". But the types of for-hire activities that are described allowed us to have sufficient confidence that a vehicle that is for-hire is indeed a commercial motor vehicle.

The VIUS provides data directly on the miles driven by for-hire operators for three different types of jurisdictions served. These are (i) interstate (whether a CMV operates in more than one state, usually under Interstate Commerce Commission [ICC]) authority (ii) intrastate (operating within one state) and (iii) local (in a single municipality). For our purposes, the intrastate and local categories were grouped into the intrastate category under the assumption that a single municipality cannot be over two states.

The main limitation in the use of the VIUS file for safety-related exposure data is that the data represent typical or primary use only. Consequently, configurations that represent secondary use, such as bobtails or doubles, are not represented at all or are under-estimated. There is very little ability to cross-classify the travel estimates by operational characteristics that are known to be associated with differences in accident-involvement risk. For example, straight trucks do a large share of their travel in urban areas and on non-limited-access roads. Tractor-semitrailer combinations accumulate a much larger fraction of their travel on limited-access roads, which are typically the safest in the highway system. The VIUS data do not provide any means of controlling for such environmental confounding factors.

C.2.3 Commodity Flow Survey (CFS)

Another source of data that could potentially be used to estimate truck exposures is the Commodity Flow Survey (CFS) which is collected by the Bureau of Transportation Statistics (BTS) and the Bureau of Census. The CFS is a survey of approximately 200,000 business establishments on origins and destinations of shipments, size of shipments, mode of transportation (truck, rail and so on) and other related information.

Each establishment on the sample reported a sample of shipment information for a two-week period in each of the four quarters of the calendar year of the survey. Shipments, by trucks, to and from 89 National Transportation Analysis Regions (NTAR's) are available from the CFS at this time. These data can be used to obtain information on the truck trip generation and attraction patterns that can ultimately provide valuable insights into where traffic monitoring equipment (for HPMS-type

activity) should be placed for optimal efficiency in estimating truck VMT, given limited resources. Routes that are taken between shipment origins and destinations have been estimated using network models (Chin, Hopson and Hwang, 1998). Shipment weights have also been estimated from the CFS (in ton-miles). Thus the ton-miles of truck shipments within, to, from and through a state are known from post-processed CFS data. From these two estimates (ton-miles and routes), it is possible to have a picture of the spatial distribution of ton-miles of commodities within a state.

C.2.4 OMC Carrier Census File

The Office of Motor Carriers (OMC) of the FHWA maintains the Motor Carrier Management Information System (MCMIS) which provides trucking firm-level data that data on the firm's mileage. There is no information on which part of the carrier's fleet incurred these miles or where the miles were driven. This data may be useful as an exposure measure only if the analysis of safety is at the carrier level (for example, if a study was intended to find out characteristics of "high-risk" carriers). However, the mileage data is not updated frequently so that it is difficult to do up-to-date studies on the basis of this dataset.

C.2.5 Motor Vehicle Registration Departments

State Motor Vehicle Registration Departments retain data on the number of registered trucks in each of several functional categories such as interstate/intrastate, for-hire or commercial. This data can serve as the "universe" to which sample-based truck mileage estimates can be factored.

C.2.6 Motor Fuel Tax Bureau

This data is retained by the Illinois Motor Fuel Tax Bureau. An interstate carrier whose jurisdiction is a member of the International Registration Plan (IRP) has to file an application for apportioned registration with its base state or province. The IRP is a program for licensing commercial vehicles involved in interstate operations among member jurisdictions. The base jurisdiction collects the license registration fee and distributes it to other jurisdictions based on the percentage of miles driven in each jurisdiction. The IRP application form requires the carrier to indicate fleet size and the number of miles traveled in each state. Because it is mandatory and is audited, this is a very reliable source of information. Mileage data are available only on heavy interstate trucks.

Motor fuel tax bureaus have data of the miles driven by trucks belonging to carriers domiciled in a particular state. This is a legal requirement, given fuel tax reciprocity arrangements among states. However, the public portion of this data is typically aggregated to all carriers in a state for a year. If this data can be released at a disaggregate to researchers, it would substantially improve exposure estimates used in carrier-level analysis.

Appendix D

Description of the Combined File and Master Identification Databases

D.1 Vehicle Identification Logic

The basic procedure is as follows:

1. Examine the license state and the license number of each CMV.
2. If the license state is Illinois, the first letter of the license plate number is a 'P' and the carrier is interstate, then CMV1 is IL-Interstate and CMV2 is Interstate. This license numbering tradition comes from the International Fuel Tax Agreement (IFTA) requirements.

   If an Illinois-based carrier operates one or more "qualified" vehicles in at least one or more IFTA-member jurisdiction, then such a license plate number is issued. The qualified vehicles are as follows:

   (a) having two axles and a Gross Vehicle Weight (GVW) or registered GVW exceeding 26,000 pounds or 12,000 kilograms

   (b) having three or more axles regardless of weight; or

   (c) used in combination and gross weight or registered gross weight of the combined vehicles exceeds 26,000 pounds or 12,000 kilograms.

   Thus, the numbering convention allows us to identify "large" interstate vehicles. Other states participating in the IFTA program have the same numbering scheme.

3. If the license state is not Illinois, the first letter of the license plate number is a 'P' and the carrier is interstate, then the CMV1 is Non-IL Interstate and CVM2 is Interstate.

4. If the license state is Illinois, the first letter of the license plate number is not a 'P' and the carrier is interstate, then the CMV1 is IL-Other and CVM2 is Interstate. CMV1 is designated to be in the "Other" category because the vehicle may be a small interstate vehicle or it may be engaged only in intrastate commerce.

5. If the license state is not Illinois, the first letter of the license plate number is not a 'P' and the carrier is interstate, then the CMV1 is Non-IL Other and CVM2 is Interstate.

6. If the license state is Illinois, the first letter of the license plate number is a 'P' and the carrier is intrastate, then the CMV1 is IL-Interstate Other and CVM2 is Interstate. This is due to the fact that although the carrier is intrastate, the vehicle, due to its special designation, is known to be allowed to drive out of state.

7. If the license state is not Illinois, the first letter of the license plate number is a 'P' and the carrier is intrastate, then the CMV1 is Non-IL Interstate Other and CVM2 is Interstate.

8. If the license state is Illinois, the first letter of the license plate number is not a 'P' and the carrier is intrastate, then the CMV1 is IL Intrastate and CVM2 is Intrastate.

9. If the license state is not Illinois, the first letter of the license plate number is not a 'P' and the carrier is intrastate, then the CMV1 is Non-IL Intrastate and CVM2 is Interstate.

Table 3.2 in Chapter 4 describes the information used for creating the two variables CMV1 and CMV2. CMV2 is a straightforward classification of whether a vehicle operating is interstate or intrastate. CMV1, on the other hand, is further qualified by in-state and out-of-state carrier and vehicle registration information.

This definitional convention has the limitation that smaller trucks (less than 26,000 pounds) that travel out of state and belong to interstate carriers or intrastate vehicles that belong to interstate carriers are classified simply into "Illinois-Other" for CMV1 and as "Interstate" for CMV2. However, the definitional issues become increasingly more complex since vehicles registered as intrastate in Illinois (and operated by intrastate carriers) can also travel out of state under special permit arrangements and should, ideally, be also considered to be interstate vehicles. Also, a vehicle may meet the criteria above and be operated by an interstate carrier but may not travel out of state, in which case the licensing convention described above will not be required. Further, a vehicle registered as intrastate may be owned and operated by an interstate carrier.

A decision was made not to use the interstate/intrastate categorization of the carrier to label a vehicle as interstate or intrastate. This is due to the fact that an intrastate vehicle operated by an intrastate carrier may travel out of state and, in fact, operate out of state. In this case, although the carrier is intrastate, the rules that apply to it are (i) the rules of the jurisdiction where it is operating or (ii) federal rules IF the federal rules imposes a higher standard (Federal Motor Carrier Safety Regulations Pocketbook, 1999). Our analysis of the Illinois State Police Inspection Files showed that

a large number of trucks owned by intrastate firms domiciled in other states operate within Illinois. This may be the case with Illinois intrastate carriers whose vehicles may also be operating out of state.

D.2 Master Identification Database (MID)

This section describes the Master Identification Database (MID) and evaluates the different databases used in terms of their contribution to the Master Identification Database (MID). As described in Chapter 4, the MID is a list of commercial motor vehicles in terms of their IDs. The purpose of creating the MID was to identify the CMVs in the IDOT Crash Files, on the basis of Vehicle Identification Numbers (VINs). But the MID can be used for a variety of other purposes as well.

Table D.1 gives information on the VIN data in the IDOT Crash Files. For the years 1994, 1995 and 1996, there are a total of 74,526 CMVs involved in crashes in Illinois. Of these, 58,644 have VINs. The remainder, 15,879, (or about 21%) have missing VIN values. Hence, it will not be possible to match these CMV's at the vehicle level even if they "exist" in any of the other data files examined. But once the remainder of the CMVs in the IDOT Crash Files are successfully linked to the MID, it is possible to identify which of the three-way category (Illinois interstate, non-Illinois interstate and Illinois intrastate) a CMV in the IDOT Crash Files to which it belongs.

Table D.1: **Vehicle Identification Numbers (VIN) in the IDOT Crash File.**

Vehicle Identification Numbers		
	Frequency	Percent
Missing	15,882	21.3
Has value	58,644	78.7
Total	74,526	100.0

When the MID was merged with the IDOT Crash Files on the basis of VINs, there was a total of 1,171,904 observations. The next step was to identify which of these could be potentially useful for correct identification of the CMVs in the IDOT Crash File. This correct identification problem may be conceptualized as a two-way table given in Table D.2. Each observation in the merged MID-IDOT database falls into one of the four cells of the table.

The category (MID=yes) and (IDOT=yes) naturally gives the number of CMVs in the IDOT Crash file that were positively identified as interstate or intrastate. This linkage process led to the positive three-way classification of 34,413 CMVs in the IDOT Crash Files. Table D.3 gives the classification of CMVs involved in crashes in Illinois which were classified according to this procedure.

Specifically, the interest is to know how many license numbers, license state and VINs could be positively identified from the OMC Crash and Inspection Files and the ISP Inspection Files. Note that in order to do the three-way categorization of CMVs, LICENSE NUMBER + LICENSE STATE

Table D.2: **Classification of CMV identification in the merged MID-IDOT File.**

		In Master Identification Database (MID)		
		Yes	No	Total
In IDOT File	Yes	34,413	40,113	74,526
	(%)	2.9	3.4	6.3
	No	1,078,027	19,351	1,097,378
	(%)	92.0	1.7	93.65
	Total	1,112,440	59,464	1,171,904
		96.9	5.15	100.0

Table D.3: **Illinois CMV crashes that could be identified by type of CMV.**

Category	Frequency	Percent
Illinnois Interstate	7,229	21.01
Illinois Intrastate & Other	4,395	12.77
Non-Illinois Interstate	22,837	66.36
Total	34,413	100.0

+ VIN are needed. If any of these variable values are missing in a record, then that record is useless for the three-way categorization of CMVs in the IDOT Crash Files.

Table D.4 shows the total number of records from the OMC Crash Files. Section C.1.2 in Appendix C describes some issues with the OMC Crash File in terms of its representation of the total number of crashes within the United States. Item I shows that of a total of 498,978 crashes, about 88% (or 440,946) crashes had the data to allow us to make positive allocations to the three-way classifications. These allocations were on the basis of license plate and license state variables, as described above. Item II shows that 106,672 (or about 21%) of these were crashes where the CMVs involved did not have identifiable VINs or they were blank. Hence, these crashes cannot be used to allocate CMVs in the IDOT Crash File, because the latter file requires linking only on the basis of VINs. Items III and IV show that about 15% of crashes had missing license numbers and about 12% had missing license state numbers.

For the MID, the interest lies in retaining exactly one record per CMV. Of the CMVs involved in the 498,978 crashes nationwide, some were involved in more than one crash. The OMC Crash File led to the identification of 368,177 unique CMVs on the basis of their VINs (this is given in Item IV of Table D.4). Item V shows that of these CMVs, 346,950 (about 94%) also had their license numbers AND license state values. Item VIII gives the three-way classifications of these 346,950 CMVs. About 94% of these are interstate CMVs that were registered in states other than Illinois. About 6% were interstate CMVs registered in Illinois and 1% were intrastate Illinois CMVs.

Table D.4: **MID-relevant information available in the OMC Crash Files**

Crash-related identifiers		
I. Type of CMV involved in crashes		
	Frequency (of crashes)	Percent (of crashes)
Category 1: IL-Inter	24,690	4.9
Category 2: IL-Intra & Other	5,998	1.2
Category 3: Interstate	410,258	82.2
Unknown :	58,032	11.6
Total :	498,978	100.0
II. Vehicle ID Numbers (VINs)		
	Frequency (of crashes)	Percent (of crashes)
Missing	106,672	21.4
Has value	392,306	78.6
Total :	498,978	100.0
III. License Numbers		
	Frequency (of crashes)	Percent (of crashes)
Missing	76,757	15.4
Has value	422,221	84.6
Total :	498,978	100.0
IV. License State		
	Frequency (of crashes)	Percent (of crashes)
Missing	58,032	11.6
Has value	440,946	88.4
Total :	498,978	100.0
CMV-related identifiers		
V. Unique CMVs identified	368,177	
VI. License Number AND State for unique VINs		
	Frequency (of CMVs)	Percent (of CMVs)
Number missing/state missing	18,195	4.94
Number missing/state available	3,032	0.82
Number available/state missing	0	0
Number available/state available	346,950	94.23
Total	367,177	177
VII. Type of CMVs identified for MID		
	Frequency (of CMVs)	Percent (of CMVs)
Category 1: IL-Inter	20,698	6.0
Category 2: IL-Intra & Other	5,055	1.5
Category 3: Interstate	324,230	93.5
Total :	346,950	100.0

Table D.5 shows the number of positive three-way categorization identifications from the ISP Inspection Files. The data used were from the years 1993 to 1998. Approximately 74% of the units inspected are interstate, with 19% licensed within Illinois and about 54% licensed in other states. About 26% of the CMVs inspected in Illinois were licensed to conduct intrastate commerce. A total of 987,608 positive three-way classifications could be made using this data, in fact for each vehicle unit inspected. The license numbers and license states of all vehicle units inspected were available in the database (that is, there were no missing values). Note that the VINs of about 0.5% of these vehicles could not be positively identified, so that these CMVs cannot be matched with the CMVs involved in crashes in the IDOT Crash File. The total number of unique CMVs identified from this database is 772,504. These VINs, license number and license state of these CMVs are known and therefore they are eligible for recording in the MID.

The MID, using only the ISP Inspection File and the OMC Crash File for the entire country yielded 1,116,253 distinct VINs. This means that about 25 thousand CMVs are common between the two files. Out of this, roughly 2% did not either a license number or a license state identification. Thus, the MID contains 1,095,026 observations in which the VIN, the license number and the license state were all available. These are the observations against which the 26,568 CMVs with VINs in the IDOT Crash File will be compared in order to classify the CMVs that were involved in crashes in Illinois.

The MID also contains data from the OMC Inspection Files. These are very large files and contain data on a large part of all CMVs belonging to interstate carriers over the entire United States from 1993 to 1998. Out of 8,200,000 inspections in the OMC Inspection Files, there were:

1. 580,527 VINs
2. 8,197,367 license state names and
3. 8,047,618 license plate numbers.

Looking at the case where there were all three appear in the same inspection record, there were

1. 56,556 for Illinois Interstate CMVs
2. 17,592 for Illinois-Intrastate or Illinois-Other CMVs and
3. 466,917 all together, Illinois and non-Illinois CMVs.

This information is summarized in Table D.6. The MID, with data from the three sources, OMC Crash Files, OMC Inspection Files and the ISP Inspection Files have complete identifiers on about 1.5 million CMVs.

Table D.5: **MID-relevant information available in the ISP Inspection Files**

Inspection-related identifiers		
I. Type of CMV involved in inspection		
	Frequency (of inspections)	Percent (of inspections)
Category 1: IL-Inter	187,816	19.0
Category 2: IL-Intra & Other	261,385	26.5
Category 3: Interstate	538,407	54.5
Total :	987,608	100.0
II. Vehicle ID Numbers (VINs)		
	Frequency (of inspections)	Percent (of inspections)
Missing	4,878	0.5
Has value	982,730	99.5
Total :	987,608	100.0
III. License Numbers		
	Frequency (of inspections)	Percent (of inspections)
Missing	0	0.0
Has value	987,608	100.0
Total :	987,608	100.0
IV. License State		
	Frequency (of inspections)	Percent (of inspections)
Missing	0	0.0
Has Value	987,608	100.0
Total :	987,608	100.0
CMV-related identifiers		
V. Type of CMV identified for MID		
	Frequency (of CMVs)	Percent (of CMVs)
Category 1: IL-Inter	120,896	15.7
Category 2: IL-Intra & Other	191,262	24.8
Category 3: Interstate	460,346	59.6
Total :	772,504	100.0

Table D.6: **MID-relevant information available in the OMC Inspection Files.**

I. Total CMV Identifiers	
VIN	580,527
License Nos.	8,197,367
License State	8,047,618
II. CMVs identified for the MID	
Category 1: IL-Inter	56,556
Category 2: IL-Intra and Other	17,592
Category 3: Interstate	466,917

D.3 The Combined File

The first step in the linking process is to identify the different variables that are to retain in from ISP Inspection Files, the OMC Crash Files and the IDOT Crash Files. The linking process is initiated by combining all relevant components of the ISP database into one file, which will be called the Combined ISP File. The details of this step are given in Appendix B.

The first link was between the OMC Crash File to the Combined ISP Inspection Files. This looked for crashes involving a CMV that took place anywhere in the country within a time window of 365 days after that CMV was inspected in Illinois. The ISP Inspection Files are from years 1993 through 1998 and the OMC Crash File contains data from 1993 through October 1998. But looking at the number of crashes that are recorded in the OMC dataset it was inferred that it would be safer to consider that the OMC database is completely updated till January 1998 only. Therefore, the OMC Crash File information till January 1998 with the Combined ISP Inspection File till January 1997 with a 365-day window also applicable to the earliest available inspection record for the year 1993 was linked.

There are two possible ways of merging the two datasets. The first one is by using the Vehicle Identification Number (VIN) and the second one by using the license/registration plate numbers of CMV's. Both data sets contain this information. This case found that the VINs were not available for all the records in the inspection files so the license plate numbers also to increase the probability of finding a match between the inspection and crash files was used. Again, since the OMC crash file contains a large number of variables, we selected the few variables that were necessary to estimate the safety index of a CMV.The information on these variables was isolated from the main OMC crash file and stored in a large array.

The program used to link the two files first reads the ISP Inspection File for VIN numbers. Information from each crash with a matching VIN in the inspection files was added to the combined data and the record was written to an output file. After the first run of the program using the VIN, a second matching run was carried out using the license/registration plate numbers and more records were added to the combined file and written to an output file. Duplicate crashes recorded by using

both the VIN number and the license/registration plate number are added to the file only by using the crash date as a check. Only one crash per day per vehicle is recorded in the final output of the combined inspection-OMC crash files.

Starting from the ISP Inspection File, the program looks for crash records of each inspected vehicle in both the OMC Crash File and the IDOT Crash Files. This is done for a one-year time window after the inspection event. If one of more crash record for an inspected vehicle is found, then that information is added to the final Combined File. If no record is found, then the Combined File only retains the vehicle's inspection history.

The Combined File contains a total of 345 variables. Each observation in the file is for a vehicle that was inspected. Recall from Table D.5 that between the time period from 1993 through 1998, a total of 987,608 vehicle units were inspected in Illinois. The Combined File contains data on each of these vehicle units. A variable termed NUM_VIO sums the total number of violations each vehicle unit incurred during that inspection. A variable NUM_ACD sums the number of crashes that each of these units were involved in, within the 365 day window after the inspection.

The Combined File contains information on the vehicle's inspection history and its crash history. In addition, it includes identifiers such as license number and license state and the USDOT and other identifiers of the carriers to which the vehicle belongs. The combined file also includes the data on the variables created for the purpose of this study, CMV1 and CMV2 as well as CARRIER1 and CARRIER2.

Appendix E

Estimation Issues in Model of CMV Risk

There are three discussions that need to occur here with regard to the estimation of the model presented in Section 4.3.4. The results of this model were discussed in Section 6.6 of Chapter 6.

Various researchers have used a negative binomial form when estimating crashes. This is typically done when there is evidence of overdispersion in the data, that is, if the observed variance is ϕ var $[\epsilon_i]$ where var $[\epsilon_i]$ is the conditional error variance and ϕ is the overdispersion parameter (if there is no overdispersion, ϕ should equal 1]. However, we found little evidence of overdispersion in the data; consequently, we went with the binomial structure.

The second pertains to the fact that the mileage data introduced in the model are estimates with their own variance structure, as opposed to actual measurements [the ideal measurement would be the annual number of miles driven by each CMV in the Combined File]. In other words, the mileage levels introduced represent only a sample of a much large set of potential mileage levels. Hence, this factor [miles] should have been introduced into the model as a random effect to allow the model to explicitly recognize the fact that the mileage effects used actually are a part of a much larger set of levels that constitute a population of effects with a probability distribution. Here we are essentially treating it as a fixed effect. The model that should have ideally been considered is a generalized linear mixed model. This is left for future research.

A third issue is that, very often, data on roadside inspections are not considered to be valuable, because they are not "random". In other words, inspections are not conducted of a random sample of the vehicle, hence basing a model of crashes on inspected vehicles only are viewed as leading to biased estimates. In reality, bias can occur only in two ways; if an important exploratory variable has been left out or if the functional form of the model is not correct.