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Report to Congressional Requesters

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FREIGHT TRUCKING

Promising Approach for Predicting Carriers' Safety Risks

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Program Evaluation and
Methodology Division

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The Honorable Robert A. Roe, Chairman
The Honorable John Paul Hammerschmidt
Ranking Republican Member
Committee on Public Works
and Transportation

The Honorable Norman Y. Mineta, Chair
The Honorable Bud Shuster
Ranking Republican Member
Subcommittee on Surface
Transportation
Committee on Public Works
and Transportation
House of Representatives

In response to the Committee's letter of August 3, 1989, we present herein information on whether certain economic or related factors could be used as predictors of accident rates in the freight-trucking industry. Fully validated predictors could be a step toward developing techniques to identify and prevent potential safety problems.

We believe we have been successful in identifying a number of problem predictors. In particular, it is worth noting that firms in the weakest financial position tend to have the highest subsequent accident rates.

As we arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies of the report to other interested congressional committees, the Secretary of Transportation, and the Administrator of the Federal Highway Administration, and we will make copies available to others upon request.

If you have any questions or would like additional information, please call me at (202) 275-1854 or Robert L. York, Acting Director for Program Evaluation in Human Services Areas, at (202) 275-5885. Other major contributors to this report are listed in appendix VII.

Sincerely yours,

Eleanor Chelimsky
Assistant Comptroller General

Executive Summary

Purpose

Freight trucks pose special safety risks. Over 4,000 people are killed annually in accidents related to heavy trucks. Fatalities are about twice as likely in accidents involving tractor-trailer trucks as in those involving automobiles only.

In recent years, the Congress has approved legislation to prevent situations that give rise to unsafe trucking operations. As a means toward this end, the House Committee on Public Works and Transportation and its Surface Transportation Subcommittee requested that GAO determine whether certain economic and other conditions could be used as predictors of safety outcomes. GAO's study had the following three objectives: (1) to formulate a predictive model specifying hypothetical relationships between safety and a set of conditions in the trucking industry; (2) to assess the availability and quality of federal data required to test the model; and (3) to use available data, to the extent possible, to develop a set of indicators that would predict safety problems in the freight-trucking industry.

The value of a workable model is that the Department of Transportation (DOT) could use it as an early warning system for predicting safety problems.

Background

Although the Motor Carrier Act of 1980 codified the relaxation of federal economic control over the trucking industry, the Congress approved legislation in the 1980's designed to monitor and prevent situations that result in unsafe trucking operations.

GAO developed a model that hypothetically links changes in economic conditions to declining safety performance in the freight-trucking industry. (See pages 18 through 23.) The hypothesis is that a decline in economic performance among motor carriers will lead to declining safety performance in one or more ways, described by five submodels: (1) a lowering of the average quality of driver performance, (2) downward wage pressures encouraging noncompliance by drivers with safety regulations, (3) less management emphasis on safety practices, (4) deferred truck maintenance and replacement, and/or (5) introduction of larger, heavier, multitrailer trucks.

Results in Brief

GAO's preliminary findings, using data on 537 carriers drawn from both DOT and the Interstate Commerce Commission (ICC), are that seven financial ratios show promise as predictors of safety problems in the interstate trucking industry. For example, three measures of profitability—

return on equity, operating ratio, and net profit margin—were associated with subsequent safety problems as measured by accident rates. The data agreed with GAO's model for five of seven financial ratios: Firms in the weakest financial position had the highest subsequent accident rates. GAO also used a number of other factors to predict safety outcomes, including the following. First, the smallest carriers, as a group, had an accident rate that exceeded the total group's rate by 20 percent. Second, firms operating closer to a broker model—that is, those that rely on leased equipment and/or drivers to move freight—had a group accident rate 15 to 21 percent above the total group's rate.

With regard to two of the submodels (driver quality and compliance), driver's age, years of experience, and compensation were all good predictors of safety problems. GAO's evidence is generally consistent with the model's hypotheses since younger, less experienced drivers and lower paid company drivers posed greater-than-average accident risks.

GAO's study thus demonstrates the potential for developing preventive strategies geared to differences among carriers and drivers, and it also suggests the importance of monitoring by DOT of the variations in carrier accident rates in order to have a sound basis for developing those preventive strategies.

GAO's Analysis

Available Federal Data

To identify and evaluate data to test a carrier-safety model, GAO reviewed the literature, talked with industry experts, and conducted interviews with federal officials responsible for maintaining data sets. GAO then combined data provided by DOT and ICC to conduct analyses. GAO found that existing federal data sets did not bring together the necessary data to fully test this model. The federal collection of truck accident data was essentially independent of the gathering of economic data, and combining the two types of data from separate federal sources was generally impractical. Most importantly, the federal data allowing calculation of accident rates for individual motor carriers did not provide for a generalizable picture of a definable segment of the industry or an analysis of safety trends over time. The needed information about truck drivers and their accident rates was also lacking. As a result, GAO could test only two of the submodels (by obtaining data from two private surveys). One unfortunate implication of this is that even if all of the submodels do prove to have predictive validity, existing federal data bases still do not contain sufficient information to convert the model to an effective monitoring system. (See chapter 3.)

Economic Predictors

GAO judged that the best available accident rate data to combine with ICC's extensive financial data are those obtained from DOT's safety audits. Since the safety audits were discontinued after October of 1986, GAO's analysis was limited to the larger, for-hire ICC carriers with financial reporting requirements that were also audited by DOT during the years 1984-86.

GAO found evidence among these interstate carriers that carriers in different markets or different financial situations pose different safety risks. For example, carriers with losses of 0.3 percent or more on equity had a group accident rate (rates are defined as accidents per million miles) 2 years later that was 27 percent above the overall group's rate. (See pages 34 through 47.)

Predictors From the Driver Quality Submodel

One of the private surveys GAO used supplied data on approximately 1,300 interstate drivers serving Florida in 1989. As was predicted by the driver quality submodel, GAO found that younger and less experienced truck drivers were more likely to be in accidents. For example, the odds for drivers aged 21 to 39 having been involved in an accident in the prior 12 months were higher than the odds for drivers over age 49 by a factor of 1.6. (See pages 50 through 54.)

Predictors From the Driver Compliance Submodel

The other private survey GAO used yielded pertinent data from a national sample of drivers in rail-competitive trucking. GAO found that lower paid drivers were more likely than their higher paid counterparts to violate safety regulations, but only in the case of company drivers and excluding owner-operators (those drivers owning their own trucks). Among company drivers, those earning less than 18.5 cents per mile had about twice the odds of having received either speeding or hours-of-service citations (or warnings) in the past 90 days.

Recommendation to the Secretary of Transportation

The monitoring, enforcement, and policy-making value of much of the truck accident information gathered by DOT is lessened by the inability to construct accident rates. Although DOT already collects accident data, the mileage data required to calculate accident rates are not routinely collected from carriers. As a first step toward reducing the accidents of motor carriers, GAO therefore recommends that the Secretary of Transportation direct the Administrator of the Federal Highway Administration (FHWA) to require that mileage data on motor carriers falling under FHWA regulations be obtained annually to improve accident analysis. How such data are obtained may depend on a number of considerations, such as costs and respondent burden, but the foremost consideration should be that data obtained allow for the calculation of accident rates for carriers falling under FHWA safety regulations in order to support monitoring and enforcement efforts and to permit analysis of safety trends.

In implementing GAO's recommendation, DOT should consider further development of predictors of safety problems. For example, GAO's analysis suggests that indicators of financial health, market segment, and driver information may be useful to DOT in identifying higher risk groups of carriers for closer monitoring or enforcement efforts. More work needs to be done in validating these preventive indicators and identifying other predictors of safety outcomes. DOT should consider advancing this work on preventive indicators because, if successful, it would signal the policy changes needed to avoid or abate the predicted unsafe conditions. GAO's demonstration illustrates the kind of work that DOT will be able to do in prevention, particularly if better information on accident rates and economic and other intermediate factors is developed. (See pages 61 through 64.)

Agency Comments

In their comments, DOT recognized the need for better mileage information and stated that it will begin research to identify measures of truck exposure and predictors of safety problems. However, DOT disagreed with GAO's original draft recommendation to obtain mileage data from carriers, especially if this meant original data collection. DOT cited the cost and burden of data collection, the limited usefulness of mileage data without stratification by other exposure factors such as road type. GAO agrees that such issues should be considered and has clarified its recommendation to indicate that DOT could obtain this information in a variety of ways. But while GAO's report exemplifies the fact that some of the research needed to reduce safety risks is feasible to perform, it also shows the serious impediments to that research created by the lack of mileage information adequate for monitoring, policy, and enforcement efforts. GAO believes that it is a matter of urgent public interest for DOT to facilitate, if not itself pursue, such research. Therefore, GAO believes that, in deciding on a means for obtaining mileage data, DOT should reconsider the matter of directly collecting them from carriers.

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Abbreviations

CARDfile	Crash Avoidance Research Data file
CFR	Code of Federal Regulations
DOT	Department of Transportation
FARS	Fatal Accident Reporting System
FHWA	Federal Highway Administration
GAO	General Accounting Office
GES	General Estimates System
ICC	Interstate Commerce Commission
LTL	Less than truckload
MFTWS	Motor Freight Transportation and Warehousing Survey
NASS	National Accident Sampling System
NMTDB	National Motor Transportation Data Base
RCCC	Regular Common Carrier Conference
SAFETYNET	The Motor Carrier Safety Information Network
TIUS	Truck Inventory and Use Survey
TL	Truckload

Safety in the Trucking Industry

Some people carry in their mind's eye a particularly frightening image of the American highway: A powerful semitrailer truck careens at high speed down a crowded interstate highway; the driver, anxious to meet a tight delivery schedule in the face of stiff competition, keeps himself awake with amphetamines as he weaves through traffic at speeds exceeding the legal limit. The destructive potential inherent in this image is realized in nightly news scenes of jackknifed or overturned trucks and flattened passenger cars, and by statistics indicating that (1) fatalities are about twice as likely in accidents involving tractor-trailer combinations as in those involving automobiles only; (2) over the period 1985-89 about 4,900 people, on average, died annually in crashes involving heavy trucks; and (3) at least 21 percent of the long distance truck drivers serving one state (Florida) were estimated to be on schedules that required them to speed.[1]

Dramatic as this image may be, is it accurate? Have the economic pressures on trucking firms led to practices that endanger public safety? In this report, we address this issue by developing and partially testing a predictive model linking economic and other factors affecting the freight-trucking industry to safety outcomes.

Background

Many factors may affect safety in the freight-transportation industry. Among these factors are economic considerations, such as profits, labor costs, and labor quality, that may result in changes in safety outcomes—for example, in accident rates—through a complex network of relationships. In the trucking industry, some of these factors were long regulated by the Interstate Commerce Commission (ICC).

Legislative and Regulatory History

Historically, the trucking industry has tended toward proliferation of firms and intense competition for market share. This tendency clearly prevailed before national economic regulation of the industry in 1935. States had earlier sought to impose controls over the industry, especially during the 1920's. While the states were able to regulate intrastate operations of motor carriers, decisions of the Supreme Court curtailed their attempts to regulate carriers' interstate operations.[2]

[1] Many heavy—that is, with a gross vehicle weight exceeding 26,000 pounds—commercial trucks have a tractor-trailer configuration. The last estimate was derived from a 1987 survey. See Richard Beilock, 1987 RCCC Motor Carrier Safety Survey (Alexandria, Va.: Regular Common Carrier Conference, 1988).

[2] In Buck v. Kuykendall, 267 U.S. 307 (1925), for example, the Court ruled that state regulation of a motor carrier's interstate operations for the purpose of limiting competition was unconstitutional.

With support from both railroads and large motor carriers, the Congress passed the Motor Carrier Act of 1935 authorizing ICC to regulate interstate motor carriers. ICC thus came to control operating authority, rates and rate-making procedures, driver qualifications, hours of service, and operational and equipment safety requirements. Though many other laws affecting the trucking industry were later passed, economic regulation was significantly changed by the Reed-Bulwinkle Act of 1948, which granted rate bureaus limited immunity from antitrust laws. This ruling allowed carriers affiliated with a bureau to set rates for their region collectively, with the rate bureau then submitting the tariff to ICC for approval.

The long-standing political belief in the efficacy of the regulatory regime was gradually reversed in the 1970's, as a consensus developed that government economic regulation was retarding the growth and efficient operation of the economy. With respect to the trucking industry, these concerns found their expression in the passage of the Motor Carrier Act of 1980.

Two critical provisions of this act directed ICC to relax requirements on entry and rate-making. The legal burden on entrants of proving the need for their services was reduced. ICC carriers were also granted new rights to determine their own rates as long as the changes did not exceed 10 percent of their previous rates.

Although federal economic regulation lessened after the Motor Carrier Act of 1980, the Congress passed several acts during the 1980's that strengthened federal safety regulations or promoted more uniformity across federal and state regulations. The Surface Transportation Assistance Act of 1982 included two major provisions. First, it established the Motor Carrier Safety Assistance Program, a grants-in-aid program to states for inspection and enforcement programs aimed at commercial motor vehicles. Second, it preempted state regulations concerning dimensions and weight on the federal interstate highway system by (1) requiring states to allow truck tractors with semitrailer-trailer combinations to a maximum of 28 feet in length (for each trailer) or single semitrailers to a maximum of 48 feet in length to operate, and (2) prohibiting the states from restricting vehicle weight to less than 80,000 pounds on the federal interstate system.

The 1984 Motor Carrier Safety Act directed the Department of Transportation (DOT) to establish safety fitness standards for carriers. It also mandated that DOT undertake a 5-year study to identify state laws and regulations affecting motor carrier safety that were either more or less stringent than federal regulations. Those less stringent then would be preempted.

In 1986, the Congress passed the Commercial Motor Vehicle Safety Act, which was designed to remove unsafe and unqualified drivers from the nation's highways. The act prohibited operators from holding more than one state license, a tactic employed by drivers with poor records to avoid suspension or revocation. To assist with the enforcement of the single-license requirement, DOT was directed to create a Commercial Drivers License Information System by January 1, 1989. Drivers are required under the act to be road-tested in a vehicle similar to those they will operate; the act also calls for minimum scores on written tests to be established. As part of rules for disqualifying drivers who drive under the influence of alcohol (or a controlled substance), the act also mandated that DOT establish a maximum blood-alcohol concentration standard for all commercial vehicle operators.

The Freight-Trucking Industry

The freight-trucking industry is divided into two major market segments comprised of private and for-hire carriers. Private carriers haul freight as an integral part of a larger business. A supermarket chain operating its own fleet of trucks to deliver produce to its stores would be an example of a private carrier. For-hire carriers are paid to carry freight belonging to others.

Obviously, carriers are tied into the economy differently depending on the commodities hauled and shippers serviced. The operations of a private carrier are most directly affected by the financial health of the firm to which it is an adjunct. In contrast, a for-hire carrier of specialized freight (such as gasoline or heavy machinery) may depend more on the market supply and demand for a particular commodity than on the financial health of a single firm. A for-hire carrier of general freight may be even more insulated from an economic downturn in any particular firm or for any particular commodity. Finally, for-hire carriers are presumedly more vulnerable than private carriers to fluctuations in the economy because they lack the long-term commitment associated with servicing a parent firm.

Another major market segmentation among for-hire carriers is between less-than-truckload (LTL) carriers and truckload (TL) carriers. LTL carriers carry loads composed of shipments from more than one shipper, whereas TL carriers transport cargo in full loads provided by a single shipper (although a TL carrier may service more than one shipper). Since LTL carriers service shippers needing to transport less-than-full-load shipments, these carriers are organized around systems of terminals at which loads of shipments are collected and dispatched. The terminal operations make LTL carriers more capital intensive and more easily unionized than TL carriers, and result in the two types of carriers having different cost and rate structures.

Different market segments and operating strategies may pose different safety risks. For example, carriers whose operations involve more driving on other than rural interstate highways are likely to have higher accident rates due to the greater risks of the roads on which they drive. In addition, while the leasing of owner-operators (drivers who own their own trucks) rather than hiring employees and buying equipment is an operating strategy that gives a carrier flexibility for expanding or contracting operations without large investments in capital, those carriers adopting this strategy may pose a greater safety risk because owner-operators are believed by many in the industry to be less safe drivers.[3]

Safety Measurement Issues

There are two basic categories of indicators for safety—"outcome" and "prevention" indicators. Most national data bases are constructed around outcome indicators such as deaths, injuries, or accidents. Trend analyses based on these data (however reliable) provide mixed evidence for whether increased concern about truck safety is necessary. Although the number of accidents involving heavy trucks in 1986 was 26 percent higher than the number in 1982, the rate of DOT reportable accidents per mile for heavy trucks continued its long-term decline over that period.[4] Similarly, a GAO report indicated that the involvement rate of medium and heavy trucks in fatal accidents, measured per million registered trucks, declined between 1980 and 1986.[5] In contrast, another report noted that estimates of accidents involving heavy trucks (derived from police reports) increased slightly faster than truck-miles traveled

[3]For example, in a 1986 survey of truck drivers serving Florida, over 60 percent of the drivers perceived owner-operators as more likely than fleet drivers (for-hire or private) to speed or violate hours-of-service regulations. Most of the remaining drivers viewed these groups as equally likely to break these rules. See Richard Beilock, 1986 Motor Carrier Safety Survey, Regular Common Carrier Conference, 1987.

[4]An accident is reportable if injuries, deaths, or damage (above a minimum threshold) occurs. For the analysis, see Richard Beilock, Russell Capelle, Jr., and Edith Page, "Speed and Training Factors Associated with Heavy Truck Accidents," Transportation Quarterly, 43:4 (October 1989), pp. 571-89.

[5]See Highway Safety: Trends in Highway Fatalities 1975-87, GAO/PEMD-90-10 (Washington, D.C.: March 1990).

between 1981 and 1986, which implies a slight increase in the rate of truck accidents per mile.[6]

There are, however, several problems in relying solely on such outcome indicators. First, the reliability of figures on heavy truck accidents, especially nonfatal accidents, as well as the appropriateness and reliability of mileage estimates used for constructing national accident rates, are open to question. Second, a deeper conceptual issue is whether outcome indicators are the most appropriate measures of safety at all. Since the goal of safety efforts is to prevent adverse outcomes for people, it would seem that trend data on outcome indicators alone may be missing critical underlying variables that, if properly measured, might indicate problems before they translate into deaths and injuries on the highways. Indicators such as change in driver compensation and change in industry expenditures on vehicle maintenance and replacement are examples of the types of information that might be needed to enhance accident prevention.

These "prevention indicators" are the focus of this study, and trend data on some potential indicators reveal some signs of deterioration over specific dimensions or for certain segments of the industry. For example, one survey of rail-competitive trucking indicated that the nonunionized company drivers' rate per mile increased only 17 percent from 1981 to 1988, whereas average wages increased 28 percent.[7] Concern has arisen in the industry that the level of drivers' wages has contributed to a shortage of drivers and has perhaps led to the loss of experienced drivers and the recruitment of less experienced and capable drivers than were available in the past. The possible consequent decline in driver quality could have negative safety implications.

Age of equipment is another major concern. According to one source at least, the nations's fleet of heavy trucks has gotten older, rising from a median of less than 6.5 to almost 8 years of age from 1980 to 1986.[8] The concern arises from the assumption that as the service life of equipment

[6]Office of Technology Assessment, Gearing Up for Safety: Motor Carrier Safety in a Competitive Environment (Washington, D.C.: Government Printing Office, September 1988).

[7]The data for drivers' wages are from the National Motor Transport Data Base maintained by Transportation Research and Marketing. The Association of American Railroads provided us with the summary data. The average wage is the average hourly earnings of production or nonsupervisory workers on nonagricultural payrolls as determined by the Bureau of Labor Statistics.

[8]Thomas J.Donahue, American Trucking Associations, testimony before the House Committee on Public Works and Transportation, March 16, 1988.

is extended, and regardless of the quality of maintenance, it becomes more likely that the equipment will fail in operation.

A model comprised of such prevention indicators would be of use in predicting safety trends in the industry, and also could serve as a signaling mechanism for the Congress and the relevant agencies concerning what specific areas are most in need of attention and how limited safety assurance resources might best be allocated.

Objectives, Scope, and Methodology

At the request of the House Committee on Public Works and Transportation and its Surface Transportation Subcommittee, we undertook a study of factors affecting safety in the freight trucking industry. In light of the Committee's interest in developing preventive techniques to forecast situations that could be forerunners to safety problems, our objectives were as follows:

- formulate a predictive model specifying hypothetical relationships between safety and certain economic and other conditions in the industry,
- assess the availability and quality of federal data required to test the model, and
- use available data, to the extent possible, to develop a set of indicators predictive of safety problems in the freight industry.

To meet these objectives, we first developed a model that relates economic and other factors to adverse safety outcomes. We then elaborated this model with five submodels. In these submodels, we traced, over a variety of issues, theoretical paths that may link economic changes in the freight industry to adverse safety outcomes. For example, the driver quality submodel assumes that reduced profits put downward pressure on wages. Lower wage levels lead to lower overall quality, less training, and less motivation in the driver work force. The predicted outcome is an adverse effect on safety.

To develop this model, we first reviewed the extensive literature on truck safety, extracting hypothetical sets of relationships between economic factors (such as profits and labor costs), intermediate variables (such as driver quality), and safety outcomes (primarily accident rates). We then convened a panel of experts to review the model and suggest refinements. These experts represented a variety of viewpoints, including those of trucking companies, drivers, academicians, and government officials. (See appendix I.)

We then identified potentially relevant data sources both in government agencies and in the private sector. To assess the utility of these data bases for our work, we first obtained documentation on the contents of the files and on the procedures used to collect the information. Where appropriate, we conducted interviews with those responsible for collecting and/or maintaining the data bases in order to assure that the information was accurate and current, and to eliminate any ambiguities we encountered during our initial screening. Combining the information on data bases with the identification of variables for our model allowed us to select those data bases that had the greatest potential utility. We assessed these data bases on such criteria as (1) relevance of data items, (2) completeness of industry coverage, and (3) capacity to be combined with other relevant data bases.

We used these data to ascertain whether economic and other factors suggested by our model could predict truck safety. These analyses were based on a variety of statistical techniques, including group accident rates and loglinear analysis. (Our rationale for selecting these techniques is described in appendixes III and V.) The choice of a particular analytical technique was based on the technique's logical suitability to our evaluation objectives and the strength of available data. Since our data came from multiple sources and had been collected for a variety of purposes, we could apply stronger statistical procedures in some segments of the work than in others.

The scope of our study was limited to the postderegulation period of the 1980's. We assumed that, since deregulation could have changed the economic context of the trucking industry in important ways, economic predictors developed from data of an earlier period might not hold in the new context. This also means that the effect of deregulation cannot be assessed from this study because of the lack of baseline data.

We conducted our review in accordance with generally accepted government auditing standards. We had no practical way, however, to check the accuracy of the carrier or driver data that we used in our analyses. Nevertheless, we did examine the data for values that were obviously incorrect and, as a result, removed a few cases from the analyses. In the case of the ICC financial data, we also excluded cases that had failed data error checks at the time of their initial entry into computer files. We obtained official comments from DOT on an earlier draft of this report, and we incorporated their points as appropriate. DOT's comments and our response are found in appendix VI.

Strengths and Limitations of Our Methodology

The major strength of our approach was its relative efficiency. Using experts to assist in the construction and refinement of the model reduced the time needed to develop the model underlying the study, by bringing to bear accumulated knowledge of the industry and the kinds of data available to test the model. In addition, by relying on existing data bases, we reduced the costs of data collection.

The major limitation of our approach was that our ability to implement the model was dependent on the completeness and quality of the information in existing data bases. With the data available to us, we could test only portions of the model, and we could not link the economic conditions among carriers, or in the trucking industry as a whole, to intermediate factors in the submodels. Overall, these data limitations resulted in our being able to test and report on only two of the five submodels we developed.

Our work was undertaken to demonstrate the type of work that could be done to develop preventive indicators and to learn the gaps in, and weaknesses of, extant data available for these purposes. We were able to use existing data to show whether certain economic or other factors were associated with safety outcomes and thus appear to be promising preventive indicators. Nevertheless, improved data and further analyses will be needed to validate the importance of these factors as prevention indicators and to develop others. In particular, because we had safety outcome data for only a single point in time, we could not test whether changes in these factors are predictive of changes in safety outcomes.

A Model of Economic Factors and Safety

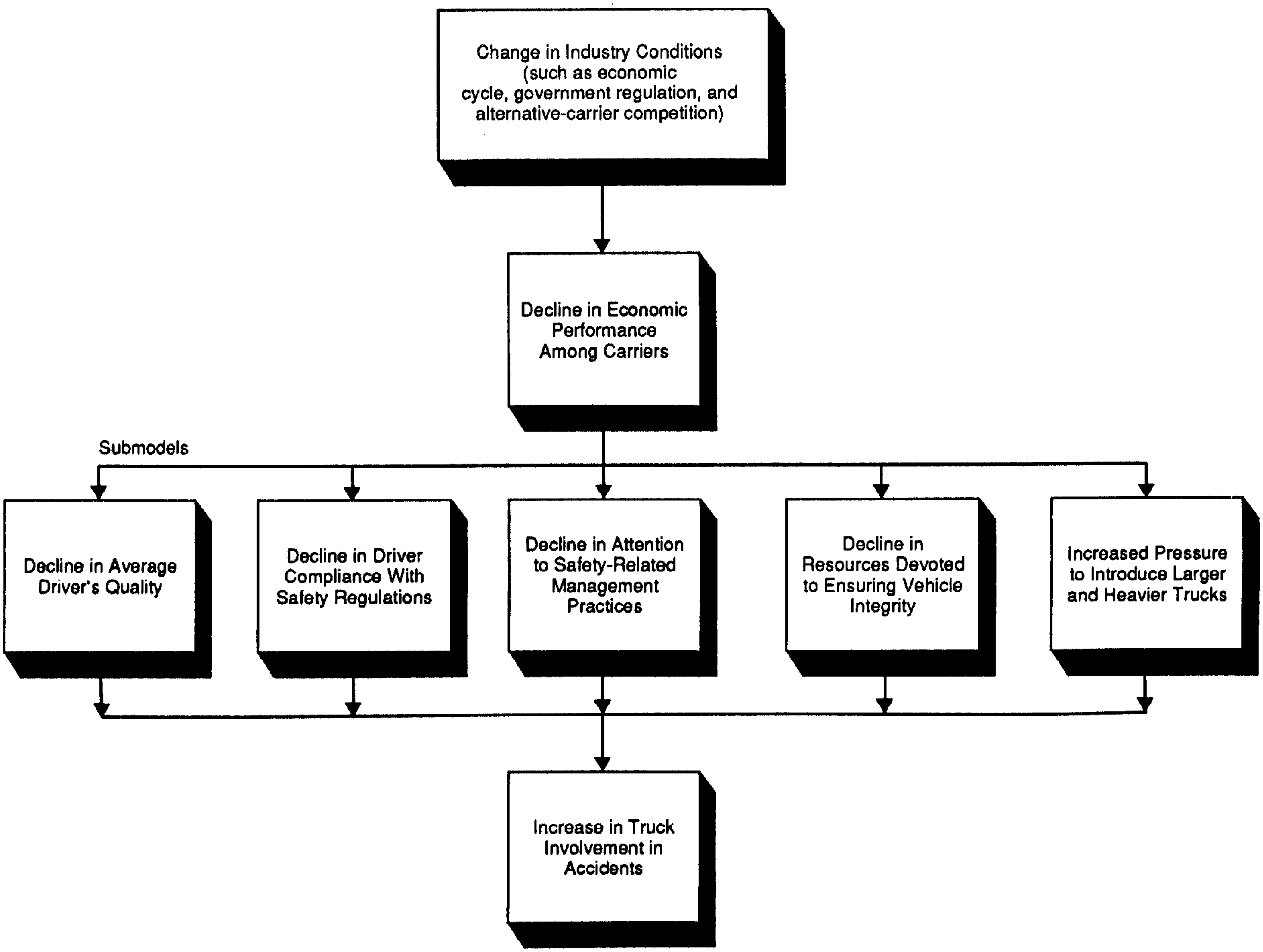
In this chapter, we fulfill our first evaluation objective—the formulation of a predictive model. The relationship, if any, between economics and truck safety may well be a complex one, involving the interactions of numerous factors and variously affecting different segments of the trucking industry. For our study, we developed a model that represents, in a relatively simple way, the relationship between economics and truck safety. From this model, we derived factors that might predict adverse safety outcomes.

Since our primary objective was to develop prevention indicators, we did not attempt to create an exhaustive model. For example, we have included major intermediate factors but not all possible safety-related factors that might be affected by economic changes. In addition, we have not included factors that may lessen safety risks. These risk-ameliorating factors might include (for instance) market discipline, which requires firms to address safety issues in order to protect their reputations with customers. Finally, our model focuses on declining economic performance; however, stable or improving economic conditions could also affect intermediate factors in ways that heighten safety risks. (To the extent that these intermediate factors are the same as the ones in our model, they would not provide additional predictors for us to examine.)

The Model

Through a review of the literature and discussions with a panel of experts, we derived a model and five submodels that hypothetically link economic conditions in the trucking industry to safety outcomes. The overall model assumes a situation in which industry conditions adversely affect carriers' economic performance and this results in a deterioration of safety performance. As shown in figure 2.1, each of the submodels constructs a different chain of intermediate links. These five submodels are (1) driver quality, (2) drivers' safety compliance, (3) management safety practices and policies, (4) vehicle integrity, and (5) vehicle configuration.

Figure 2.1: Hypothetical Linkage Between Economic-Related Conditions and Adverse Truck-Safety Outcomes



Driver Quality Submodel

According to the driver quality submodel, economic problems in the truck-freight industry may raise accident risks by lowering the average quality of drivers. The submodel proposes the following chain of deduction: If economic problems in the freight industry reduce profits for individual carriers, the carriers are less able to meet drivers' wage demands;

consequently, driving a truck becomes a less attractive occupation compared to previous times, and perhaps relative to other jobs, due to downward pressure on wages.[1] Experienced drivers are therefore more likely to leave the industry in search of better paying work, and high quality replacements are less likely to enter the industry. This loss of more capable drivers (who either leave or never enter the industry) causes a decline in the average quality of truck drivers.[2] The end result is an increase in the proportion of younger, less experienced, and less capable drivers, all of whom are more likely to become involved in accidents. (We report on a partial test of this submodel in chapter 5.)

Driver Compliance Submodel

The driver compliance submodel focuses on conditions that increase the incentives for drivers to violate safety regulations. As with the driver quality submodel, this submodel begins with the assumption that economic problems in the trucking industry constrict the profits of carriers. These conditions place downward pressure on drivers' wages as carriers try to manage their reduced profitability by controlling their operating costs.

Depending on how they are paid, drivers will have differing abilities to protect their incomes in the face of downward pressures on their wages. On the one hand, drivers who are paid on a salaried basis will tend to have no option (other than perhaps collective bargaining or changing jobs) but to watch their earnings eroded by salary reductions, forfeited raises, or inflation.

On the other hand, drivers who are paid on a rate basis (that is, per mile or per load) do have a choice. They can work at the same pace and face income erosion or they can drive harder (that is, drive more miles or

[1]According to one industry spokesman, in addition to pay, other economic-related trends may be making the industry less attractive to drivers. Decreased profitability has led to a decreased use of local drivers to drive a load in stages to a distant destination; the longer hauls for drivers have resulted in more time away from home, which is hard on families and makes it difficult for carriers to keep superior drivers. In addition, higher minimum age requirements set by insurance companies contribute to the scarcity of apprentice drivers by forcing young people to start their careers in other fields.

[2]The observed effect of the industry's becoming less attractive may actually be somewhat more complex. Older workers, whose skills are specialized to the industry, may be reluctant to leave it. At the same time, if employment in the industry is declining, the number of new entrants will drop. Thus, quality may at first improve, and then later decline. Alternatively, if the main effect is the loss of middle-aged drivers, the quality of the average driver might not change much; however, the distribution of quality might become more polarized. In the first case, one must be concerned with determining the lag before average quality declines. In either case, some measure of the average quality of new entrants, rather than of all drivers, might be more sensitive for measuring changes.

loads) to maintain or increase their incomes. However, this incentive to increase the pace conflicts at some point with safety regulations. Drivers will be tempted to violate regulations that restrict their incomes, particularly regulations concerning overweight hauls, speed limits, and hours of service that limit the number of miles or loads that can be driven over a set time period. Therefore, to the extent that drivers choose to protect their incomes, they are more likely to take risks by violating safety regulations.[3] The outcome of these greater risks is increased incidents of truck accidents. (We report on a partial test of this submodel in chapter 5.)

As developed here, the compliance submodel focuses on financial incentives for individual drivers, but other factors could also be operating. Job protection, as well as income protection, may play a part in drivers' noncompliance with safety regulations. Carriers as well as drivers could find the rewards of noncompliance more attractive under conditions of lower earnings. Carriers may view noncompliance as a way to meet the tight schedules that shippers insist on, or a way to increase revenues by moving more freight than they could if they met all regulations. In brief, carriers may have incentives to set schedules that drivers can meet only by violating speed or hours-of-service regulations. In this situation, noncompliance with safety regulations may appear to the driver to be a condition of employment.[4]

Management Practices Submodel

Much of the research into the causes of truck accidents focuses on equipment, drivers, and accident conditions. In contrast, the management practices submodel assumes that carriers' safety management practices have important consequences for accident rates. According to this submodel, carriers are less likely to develop or maintain effective risk management programs if the industry faces decreased profitability. Under conditions of decreased profitability, firms will be under pressure to control costs. Since few operating costs can be reduced in the short run, the carrier may be drawn toward a strategy of reducing the cost of maintenance, safety programs, or other safety-related areas. It might be

[3]An alternative hypothesis is that drivers with higher wage rates would be more tempted to violate income-restricting regulations because the rewards would be larger for them.

[4]Motor carriers have a legal responsibility not to pressure drivers into noncompliance with regulations. Federal regulations prohibit motor carriers from scheduling or permitting runs that would necessitate exceeding legal speed limits (see 49 CFR 392.6) or a maximum number of driving hours (see 49 CFR 395.3). Still, with or without the knowledge or encouragement of the motor carrier, the economic pressure of payment by the mile or load may create an incentive for drivers to ignore these regulations.

assumed from this submodel that carriers with established safety procedures—such as the effective monitoring of drivers' hours of service, requiring routine inspection and maintenance of vehicles, or ensuring appropriate driver qualifications and training—would have lower accident rates than similar firms that lack these policies and procedures. (However, we could not test this submodel due to technical problems with carrier management data provided to us by DOT.)

Vehicle Integrity Submodel

The vehicle integrity submodel deals with the extent to which firms maintain their vehicles in good condition. It involves the same cost containment assumption expressed in the previously discussed management practices submodel. Cost containment is presumed to occur in safety sensitive areas. This may especially be the case for economically marginal firms, which are less able to raise the capital necessary to reduce costs by purchasing new fuel-saving equipment. Instead, these carriers may meet financial constraints by deferring the costs of vehicle maintenance and replacement. To the extent that carriers adopt this option, trucks on the highway will tend to be older, more defective, and therefore more hazardous. (We could not obtain data to test this submodel.)

Vehicle Configuration Submodel

This submodel focuses on one avenue of increasing profits and revenues for the industry. In response to declining profitability, the trucking industry might find financial relief by increasing productivity or capturing market share from other modes of transportation. One way to achieve this result has been to introduce larger and heavier trucks.[5] These larger configurations have allowed carriers to be more productive movers of freight and to better compete with trains for certain types of freight.

This submodel postulates that these new truck configurations, and the even larger ones being proposed, increase accident risks on the highways. These increased risks could arise for various reasons. The potential reasons include inadequate highway designs for maneuvering the larger trucks, drivers' inexperience with different handling characteristics, and the poorer handling and stability of double-trailer trucks compared to single-trailer trucks.

[5] Maximum dimensions and weight are set by law. For example, the Surface Transportation Act of 1982 authorized the use of heavier and longer trucks than were previously allowed by some states.

Since truck configuration, size, and weight may each independently affect safety outcomes, testing this submodel would require data on each of these factors, as well as on accident rates. Ideally, such a test should also consider other safety-relevant factors, such as type of roadway. (Bureau of Census data that might have allowed a partial test of this submodel were not available during our study.)

Alternatives to the Model

The model explicated in the previous section was derived from the research literature and industry observers. This literature frequently focused on whether declining economic conditions resulted in deteriorating safety outcomes. The model we derived from this literature is plausible, and it postulates intuitively sensible relationships. However, it is also the case that variations of, and even contradictions to, the model's logic could be developed and tested.

For example, one alternative would suggest that improving rather than declining economic conditions in the trucking industry could imperil safety. One version of this argument would posit that if economic conditions (such as profitability) improved, new carriers would be attracted to the industry. Such new firms might pose higher than average safety risks, at least temporarily, for several reasons. For instance, as new firms, they might start out with less experienced drivers than more established carriers. Moreover, they would not have had the time to develop the management practices that would contribute to safer operations.

Another possible version of this alternative focuses on the financial health of individual firms that may be able to maximize their profits by operating close to their capacity to move freight. While this method of operation might be efficient for the firm, operating at this level of activity could increase the likelihood that firms would violate safety regulations—for example, by pushing drivers to operate for longer hours or at higher speeds than permitted, or by cutting corners on safety maintenance. In addition, the costs to the firm associated with slower schedules and maintenance shutdowns are greater for more successful firms. This fact could provide an incentive for the most profitable firms to take increased risks.

A completely different line of argument—that is, one which runs counter to the two alternatives just discussed—suggests that even under fairly poor economic conditions, most firms in the trucking industry are unlikely to engage in unsafe operations. This argument is based on the notion that, in a competitive marketplace, trucking firms would tend not to risk their reputations by endangering the cargoes they carry. That is, safe, efficient operation is a competitive advantage, so firms might possibly maintain or even increase their safety efforts in order to prevent a loss of customers to safer, more dependable carriers. However, this presumes a knowledge of firms' operations that is not always available.

Finally, returning to the model we use in this report, even if it were always true that declining economic conditions produced deleterious effects on safety, federal safety programs could limit these negative effects. For example, using federal funds made available through the Motor Carrier Safety Assistance Program, states expanded their inspection efforts to include nearly one million driver and vehicle inspections by 1987. In that year alone, this program resulted in hundreds of thousands of vehicles and tens of thousands of drivers being placed out-of-service. Such expanded enforcement may lead to increased compliance with safety regulations. In a second example of federal intervention, all commercial truck drivers must pass knowledge and driving tests that meet minimum federal standards by April 1, 1992, and this regulation may help ensure a minimal level of driver quality. Over time, these and other safety programs may limit the influence of any economic pressures that would otherwise increase safety risks.

Which Model to Use?

As already noted, our objective here is to identify factors that will predict safety problems arising in the trucking industry. The model and submodels serve this objective only to the extent that they direct us to predictors of safety outcomes. Our main use of the model is to derive predictors of safety outcomes. If a model leads us to select a good predictor, it is of less consequence whether the predictor operates in the direction expected. For example, if we found that financially troubled firms posed lower safety risks than healthy firms, that information could be useful for targeting enforcement activities even though it apparently conflicts with the hypothesis of the model.

A model is also more useful for our objective if it allows prediction of safety risks for a sizable portion of the trucking industry, if not the whole industry. Although our model has been presented as globally representing the trucking industry, we suspect that it and the derived predictors may have more applicability for some segments of the industry, and for certain types of carriers, than for others. This notion arises in part from considering the somewhat different markets served by the trucking industry, which were described in the last chapter. One analyst, for instance, has argued that the driver shortage (which could be a symptom of the attractiveness of the trucking industry as discussed in our driver quality submodel) primarily affects the nonunionized truckload carriers because their wages are significantly lower than those of unionized carriers and their working conditions are more rugged than those of the less-than-truckload (LTL) carriers.[6] It thus seems unlikely that the various segments of the trucking industry face exactly the same conditions or adopt operating strategies that have exactly the same safety implications.

Prior studies also support the notion that the same models and predictors may not be equally applicable across the industry and across types of carriers. For example, some prior research suggests that carriers of general freight, smaller carriers,[7] new entrants into the industry,[8] and carriers that make greater use of owner-operators[9] pose greater safety risks.

Finally, a model is more useful if it leads us to predictors that are robust over time despite changing contexts. In other words, to predict safety deterioration in firms and the industry in time to take ameliorative actions, we need to identify factors that predict accident rates for quite different time periods. We must have some concern that safety factors in the early 1980's, when carriers were responding to deregulation and the recession of 1981-83, may not be as predictive under the different conditions of the early 1990's.[10] Although there can be no assurance that predictors that worked well in the past will always work well in the future, a predictor that has performed well in a variety of past years and under a variety of conditions is more likely to be robust over time.

[6]Christopher Barnekov, "Trucking," U.S. Industrial Outlook 1989, U.S. Department of Commerce (Washington, D.C.: Government Printing Office, 1989), pp. 52-5.

[7]See Thomas Corsi and Philip Fanara, Jr., "Driver Management Policies and Motor Carrier Safety," The Logistics and Transportation Review, June (1988), pp. 153-63.

[8]See Thomas M. Corsi and Philip Fanara, Jr., "Effects of New Entrants on Motor Carrier Safety," Transportation Deregulation and Safety: Conference Proceedings, (Evanston, Ill.: The Transportation Center, Northwestern University, 1987), pp. 561-92.

[9]See Thomas M. Corsi, Philip Fanara, Jr., and Judith Jarrell, "Safety Performance of Pre-MCA Motor Carriers, 1977 Versus 1984," Transportation Journal, Spring (1988).

[10]Even during the 1980's, important conditions were changing. Federal safety legislation evolved throughout the 1980's in ways that could change the effect of economic factors on safety outcomes.

A potential limitation on the utility of our model is that the necessary data may not be available either to evaluate the usefulness of derived predictors or to monitor the industry for policy and enforcement purposes. In the next chapter, we review federal data that are relevant to the model and assess the extent to which these data are adequate for model testing and monitoring purposes.

Adequacy of Available Federal Data

Our second evaluation question asks what the availability and quality of federal data may be for testing the model outlined in the previous chapter. To answer this question, we reviewed major federal sources of accident or economic data on the freight trucking industry. We did not review all of these data sources with equal thoroughness because we found some would not meet minimal requirements to test even portions of the model or submodels. As soon as it was evident that a data source was not appropriate for our purposes, we examined it no further.

We found that existing federal data bases are not adequate to test the model fully. Some of the data sets are inadequate for testing any portion of the model. These data sets do not allow computation of accident rates, which is necessary to permit estimation of the safety risks associated with the economic or intermediate factors specified in the model. Moreover, no federal data source, or feasible combination of federal data sources, was adequate to test any of the submodels in full; this limitation results from the largely separate collection of accident data and economic data on trucking. Even those data sets that meet minimal requirements for testing portions of the model are limited by factors like their undefinable representation of the trucking industry, incomplete coverage of factors of interest, or lack of comparable data over time.

The following sections discuss in detail our criteria for adequacy of data, the federal data sources that we reviewed, and the strengths and weaknesses of these data sets for testing the model.

What Are Adequate Data?

The adequacy of data must be judged relative to some purpose, since data may be adequate for one purpose but not another. The federal data bases on the trucking industry may be quite adequate for the administrative, safety rating, educative, targeted monitoring or enforcement, research, or other purposes for which they were designed, and still be inadequate for examining the model.

Our criteria for determining the adequacy of data bases for our study are shaped by our objective of developing predictors of safety outcomes from the model. (If our objective was to test whether the model was truly causal, we would have a somewhat different set of requirements for the data.) Optimally, the data should (1) provide valid and accurate measures of the predictors and safety outcomes that are required for testing associations, (2) provide a complete and accurate picture of the industry or a definable portion of it, and (3) cover several years to demonstrate whether the predictors do predict over time and are robust predictors over various years and conditions.

These criteria can be specified in more detail to highlight some minimal requirements of adequacy:

- For our purposes, the accident data must be validly interpretable as differential safety risks since these are what we are trying to predict. Safety risks are commonly measured in terms of accident rates per mile of travel. This measure provides an index of safety risk for carriers with varying numbers of annual miles driven.[1]
- The data set, or a combination of data sets, must include items measuring the factors identified as important predictors by the model. To test at least a portion of the model, the minimal requirement is that the data base include at least one measure of safety outcomes and at least one of a predictor variable.
- The data should give a complete and accurate picture of the industry or at least a sizable, definable portion of it. A census or a random sample are the usual means for ensuring that findings provide complete and accurate coverage of a population or definable subpopulation. Lacking such a sample or census, we can be less certain about the industry segments or types of carriers to which the predictors apply. Moreover, our findings concerning the associations, whether strong or negligible, between the predictors cannot be conclusive because they may reflect biases in the sample. Nevertheless, nonrandom samples can suggest the importance of predictors in the trucking industry, even though these findings are less definitive than they could be.
- The data should preferably constitute a time series—that is, comparable data should be collected over several years rather than for a single year. We can test for an association between a predictor and safety risks measured in a single year; however, we would be unsure that the association would hold in other years, over various times and conditions. In addition, we would be unsure as to whether changes in the predictor, such as carrier profitability, would be predictive of later changes in safety outcomes. Time series data can help to resolve this issue by allowing us to examine the extent to which safety outcomes are related to economic factors in earlier years.

[1] Directly comparing the number of accidents experienced by variously sized carriers confounds safety risk with carrier size. It hardly would be surprising, or informative, to find that a carrier with one truck had fewer annual accidents than a carrier with thousands of trucks. The larger number of accidents for the larger carrier could result from its greater exposure to potential accidents rather than less safe operation on its part.

Available Federal Data

Through a literature review, interviews with agency officials, and advice from an expert panel, we identified major sources of accident and economic data collected by the federal government. These data sets, their maintaining agencies, and major focuses are listed in table 3.1. For our present purposes, the most noteworthy observation from the table is that the major economic data sets are collected independently of accident data collections; the latter are primarily maintained by various units in DOT. This separate collection of data creates problems when an attempt is made to test for associations between economic factors and accidents.

Table 3.1: Federal Data on Economics and Accidents in the Freight-Trucking Industry

Data set	Responsible agency	Major focus
Accident data		
Safety Management Audit System[a]	Federal Highway Administration (FHWA)/DOT	Detailed information on selected carriers' and shippers' compliance with federal safety regulations (includes accident rate)
Safety Review and Compliance Review		Detailed information on selected carriers' knowledge, policies, and procedures related to safety regulations (includes accident-rate information)
Motor Carrier Accident Report (Form 50-T)		Self-reported accident data required of federally regulated carriers
Fatal Accident Reporting System (FARS)	National Highway Traffic Safety Administration/ DOT	Census of all fatal accidents (includes information on truck involvement)
National Accident Sampling System (NASS)[b]		Details from a nationally representative sample of all police-reported accidents
General Estimates System (GES)		Details from a nationally representative sample of all police-reported accidents
Crash Avoidance Research Data file (CARDfile)		Details from census of police accident reports from several states
Truck Inventory and Use Survey (TIUS)	Bureau of the Census	The physical and operational traits of the U.S. truck population (includes accident-involvement questions for 1987)
Economic data		
Annual financial reports (Form M)	ICC	Detailed financial statements for ICC-regulated carriers with annual revenues of at least one million dollars
Motor Freight Transportation and Warehousing Survey (MFTWS)	Bureau of the Census	National estimates of revenue and operating expenses for firms providing local or long-distance trucking or transfer services

[a]Superseded after October 1986 by the Safety Review and Compliance Review
[b]Superseded after 1987 by GES

Adequacy of the Data

Of the eight federal data sets with truck accident data, only three—the Transportation Inventory and Use Survey (TIUS), the Safety Audit, and the Safety Review—met our minimum data requirement of providing information on accident rates. Since that information was needed for any test of our model, we evaluated only those three data sets in relation to our other data requirements.

By themselves, these three accident data sets provide almost no carrier financial data to test the economic portion of the model. The Safety Review data include a single item on whether the carrier was profitable and another on gross revenue,[2] but the other two data sets have no information on carrier finances. Moreover, we found limited possibilities of combining any of the accident data with economic information from other federal data sources, such as ICC. TIUS (organized by truck owner) cannot be combined with the economic sources (organized by firm) because of differences in units of analysis. It is technically feasible to combine the Safety Review or the Safety Audit with ICC's financial data on carriers, but the resulting overlap of covered carriers with the economic data sets is unlikely to be complete. However, the overlap is likely to be greater for the Safety Audit than for the Safety Review because the Safety Audit was more targeted toward larger firms that are also likely to have ICC financial reporting requirements. (See appendix II for further discussion of economic data sets.)

The Safety Review and TIUS data sets respectively provide extensive coverage of the intermediate factors in the management practices and the vehicle configuration submodels. However, none of the data sets provides much information on variables that could be used to examine the other submodels concerning driver quality, driver compliance with regulations, and vehicle integrity.[3]

Beyond their limited coverage of the factors of interest, two of the three data sets have the added limitation of not providing a general picture of the trucking industry. The Safety Audit and its successor, the Safety Review, provide information only on an annually targeted sample of carriers. In contrast, TIUS, as a national random sample of registered trucks, does provide a general picture of the trucking industry.

[2]Even these items may not be available in the future. A DOT official told us that FHWA is considering dropping both of these economic items from the Safety Review, citing concerns about the reliability of the oral responses from firm representatives.

[3]None of the data sets includes data on driver compensation. The Safety Audit and Safety Review do include inspection of a minimum number of records on driver qualifications, duty status, and vehicle inspection and maintenance. (The Safety Audit also includes inspection of a representative number of vehicles parked on the carrier's property, if available.) Given the leeway allowed in the inspection guidelines, however, the resulting information may not be comparable across carriers and, for the Safety Review, is designed to assess carriers' safety operations rather than their drivers or vehicles.

A major weakness, for our purposes, of all three data sets is that they do not provide analyzable data for carriers or the industry over time. The Safety Audit and Safety Review neither follow the same carriers over time nor represent a definable portion of the industry over time. Although TIUS captures a national estimate of heavy trucks (but not carriers) at 5-year intervals, it does not provide a time series on accident data because the data were first collected for the 1987 survey. Consequently, these data sets only allow for static analyses of the association between factors and safety outcomes; they do not allow for testing whether changes in the factors led to changes in accident rates.

Discussion

The limitations of extant data sets allow only partial tests of our truck safety model. (For example, in chapter 4, we test for a linkage between carrier financial standing and accident rates by combining ICC financial data with the Safety Audit data, the collection of which was discontinued in 1986.) The Safety Review data cover many issues relevant to the safety management submodel, but technical problems with the data prevented us from conducting even a partial test of the submodel.[4] The 1987 TIUS data, which would be most useful for partially testing the vehicle configuration submodel, were not available during our study because the Bureau of the Census had not then completed tabulations. Moreover, we found it necessary to obtain data from nonfederal sources to carry out partial tests of the driver quality and driver compliance submodels. (See chapter 5.) One implication of this situation is that, even if the models do prove to have predictive validity, existing federal data bases are unlikely to provide the information needed to convert our model to effective monitoring systems.

One federal data collection that is being implemented at present may solve many of the shortcomings of existing accident data sets for developing preventive measures. FHWA has developed the Motor Carrier Safety Information Network (SAFETYNET), through which states combine roadside inspection data and accident data into a national data set. Unlike existing federal data sets based on police accident reports, SAFETYNET links accident data to carriers and thus allows monitoring and analysis at the level of the firm. It will also allow cross-checking and supplement the current collection of annual, comprehensive, and national statistics for all types of truck accidents; this is particularly

[4]DOT provided us with safety review data, but the information did not fully match their documentation. A more intractable problem was that DOT entered the data into computer files in such a way that answers of "yes," "not applicable," or "no answer" are not distinguishable, a practice which creates uncertainties for the interpretation of any analysis based on the data.

important because DOT officials believe the current data collection (Form 50-T) reflects an underreporting of truck accidents of up to 40 percent. Moreover, if SAFETYNET is implemented in every state, it will provide a census and time series of the number of accidents experienced by motor carriers.

Still, even when implemented, SAFETYNET will lack important data items for monitoring problem carriers or developing preventive measures. The foremost shortcoming will be the lack of information on carrier mileage by which accident rates could be calculated. Second, although the SAFETYNET information—when combined with other FHWA information—will allow consideration of some factors that may be preventive measures, FHWA information still will lack many of the financial and submodel factors needed to test our model.

Recommendation to the Secretary of Transportation

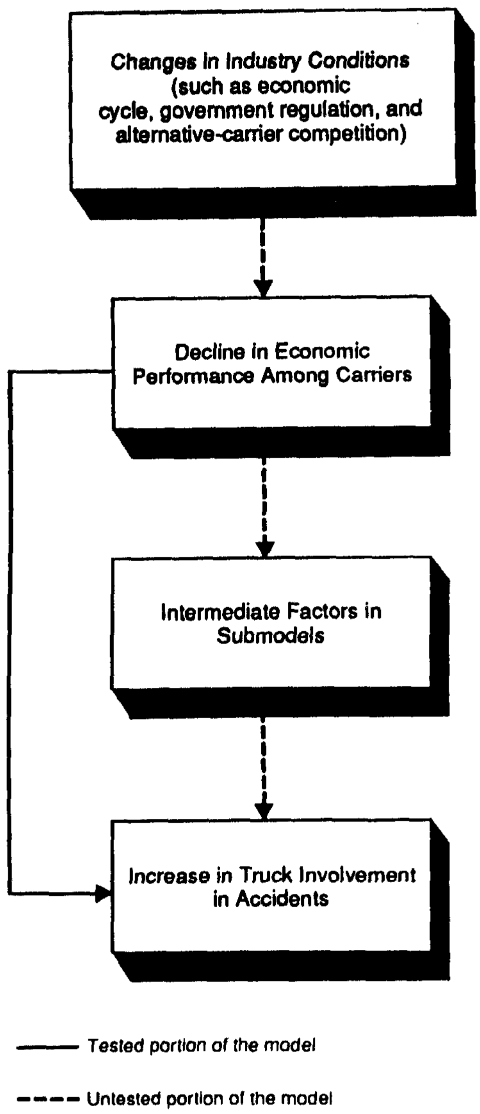
Although DOT already collects accident data, mileage data are also required for the calculation of accident rates. FHWA, for example, collects annual comprehensive accident data on interstate carriers in order to identify, mitigate, and eliminate accident causation factors; however, it collects accident rate data only for those carriers that are targeted for safety or compliance reviews. Our own effort to develop prevention indicators illustrates the barriers to the achievement of this objective created by the lack of better data on accident rates. Accident rates from administratively selected and one-time reviews, such as those currently conducted by FHWA, can provide only tentative conclusions. In short, the monitoring, enforcement, and policy-making value of much of the truck accident information gathered by DOT is lessened by the inability to construct accident rates. As a first step toward reducing the accidents of motor carriers, we therefore recommend that the Secretary of Transportation direct the Administrator of FHWA to require that mileage data on motor carriers falling under FHWA safety regulations be obtained annually to improve accident analysis. How such data are obtained may depend on a number of considerations, such as costs and respondent burden, but the foremost consideration should be that data obtained allow for the calculation of accident rates for carriers falling under FHWA safety regulations in order to support monitoring and enforcement efforts and to permit analysis of safety trends.

Findings Based on the Model: Economics and Safety Risks Among ICC Carriers

Safety enforcement officials could more efficiently allocate their resources if they could focus their efforts on high-risk carriers and those carriers with worsening risks. If the predictors specified by the five models outlined in chapter 2 can reliably identify carriers with high safety risks or warn us of intensifying safety problems, then it would be efficient for safety officials to monitor data on those predictors.

In this chapter and the next, we address our third evaluation objective, which is to develop predictive measures of safety problems. Here we examine evidence on whether industry segments or carriers' financial conditions are useful predictors of safety risks among a sample of ICC-regulated carriers that had safety audits during 1984-86. We thus explore the model's premise that economic factors are associated with safety outcomes; however, we do not analyze the various intervening mechanisms specified in the submodels. (The portion of the model that we are testing in this chapter is represented by the solid line in figure 4.1; however, we are examining levels of accident rates rather than changes in them.) First, we assess whether carriers' prior financial conditions were associated with their later accident rates. Second, we look at whether industry segment or type of carrier was associated with safety risks.

Figure 4.1: Model Linking Economic-Related Conditions and Adverse Truck-Safety Outcomes



Financial Predictors of Safety Outcomes

To examine whether measures of the financial condition of carriers can be used to predict safety outcomes, we present findings on our analyses of the relationships between a variety of financial ratios and accident rates. In each case, the data on accident rates (based on 1984-86 Safety Audits) are for the period 2 years later than that for the financial ratios (based on 1981-85 ICC financial reports).[1] Thus, we were able to consider the predictive capacity of the financial measures among a sample of relatively large, interstate, for-hire, ICC-regulated carriers. Our findings from this sample cannot be generalized to the trucking industry; however, the sample did provide a unique opportunity to bring the rich ICC financial data together with DOT accident data.

We derived a sample of 603 carriers that appeared in both data sets, which subsequently was reduced to 537 carriers that reported financial data 2 years prior to their safety audit.[2] We sought simple financial predictors of accident rates for two reasons. First, simple predictors are more easily made operational for safety monitoring, an important consideration given the relative scarcity of existing economic data on carriers. Second, the modest number of carriers in our sample limited our ability to construct complex measures or to conduct separate analyses for more than a few subgroups.

We analyzed 13 financial ratios. For each of these ratios, the sample of trucking firms was divided into five categories, each including approximately one fifth of the carriers. A group accident rate was next calculated for each category by dividing the total number of accidents by the total number of miles for those carriers in the category. We could then see how group accident rates varied over the five financial categories, ordered from lowest to highest. (See appendix III for our rationale for basing our analysis on group accident rates rather than the rates for individual carriers, and see table IV.1 for accident rates for the financial ratios.)

For our purposes, we wanted predictors that could distinguish high- from low-risk carriers simply and strongly. To identify simple predictors, we ordered the five carrier groups for each financial ratio from lowest to highest. Then we computed the group accident rate for

[1]Further study with other data sets will be necessary to determine the optimal time lag for the purposes of prediction. We chose to analyze "approximately" a 2-year separation between financial status and accident rates because of data considerations. The data for accident rates are typically not based on a calendar year, and thus had to be fitted to the closest calendar year for our analysis of annual financial data. As a result, accident periods for some firms overlap with the calendar years of their nominally 1-year earlier financial period. Two-years-prior financial data are unambiguously prior for all cases, and in this regard are better suited to test predictions. We chose not to test greater than a 2-year separation because that would require data from the pre-deregulation period for some cases.

[2]Note that not all 537 carriers appear in all analyses of financial ratios because of missing data or incalculable financial ratios for some carriers. The sample of 603 includes carriers for which we had ICC information from the year of the safety audit or a single year before it, but not for 2 years prior to it. This larger sample is used in the analyses of types of carrier presented later in this chapter.

the total group. Finally, moving from the lowest to highest group on each ratio, we counted the number of times the group accident rates crossed from above to below (or from below to above) the group accident rate for the total group. The fewer times the group rates crossed the overall rate, the simpler was the relationship between the financial ratio and the accident rate 2 years later.[3] With a single crossing, for example, the pattern is simple in the sense that it identifies a set of carriers within a single range of financial categories that have above-average accident rates. The 7 predictors showing the simplest patterns (not more than 2 crosses) are the top 7 ratios listed in table 4.1.

Table 4.1: Group Accident Rates, by Financial Ratios

Financial ratio	Difference between the accident rates of highest subgroup and total group	Crosses of total group accident rates by subgroup rates
Return on equity	0.31	1
Cash flow to current liabilities	0.16	1
Operating ratio	0.25	2
Long-term debt to equity	0.15	2
Net profit margin	0.24	2
Return on capital	0.19	2
Return on transportation investment	0.23	2
Revenue per mile	0.33	3
Turnover of net carrier operating property	0.24	3
Revenue per ton	0.17	3
Current ratio	0.11	3
Accounts receivable turnover	0.16	3
Net debt to equity	0.14	4

We also measured the degree to which these financial ratios distinguished above-average safety risks. For this purpose, we used the difference between the highest group accident rate from among the five categories of each financial measure and the group accident rate for all of the carriers. As shown in table 4.1, the strongest differences were in the range of 0.24 to 0.33 accidents per million miles. We divided these differences by the group accident rate for the total sample (about 1.13

[3]This technique for discerning simple patterns might be misleading in some instances. For example, most categories might closely approximate the average accident rate but slightly fluctuate above and below it, and one other category might clearly exceed the average. In this case, the technique would indicate a complex pattern where a rather simple pattern actually existed. However, we observed no such misleading cases in applying this technique to the 13 financial ratios examined here.

per million miles), thereby calculating that these high-accident-rate groups exceeded the total group's rate by 21 to 29 percent.

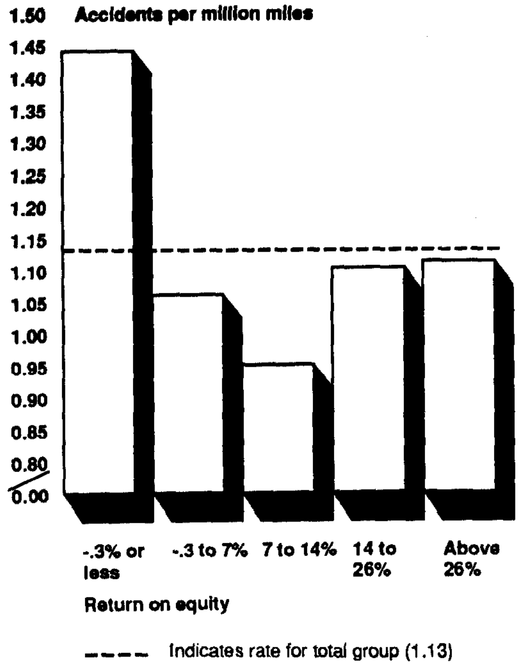
In this chapter, we discuss our findings only for the seven financial ratios showing the simplest relationships with accident rates. (Findings for all the financial ratios are located in appendix IV.)

Profitability

Five of the seven financial ratios—operating ratio, net profit margin, return on equity, return on transportation investment, and return on capital—measure profitability. All five of these ratios show similar relationships with accident rates. In each case, the pattern of accident rates is curvilinear ("U" shaped), but asymmetric in that the rates are highest at the less profitable end of the scale. That is, the lowest level or levels of profitability are associated with the highest group accident rate, the intermediate level or levels of profitability with the lowest group accident rate, and the highest level or levels of profitability with the intermediate group accident rate.

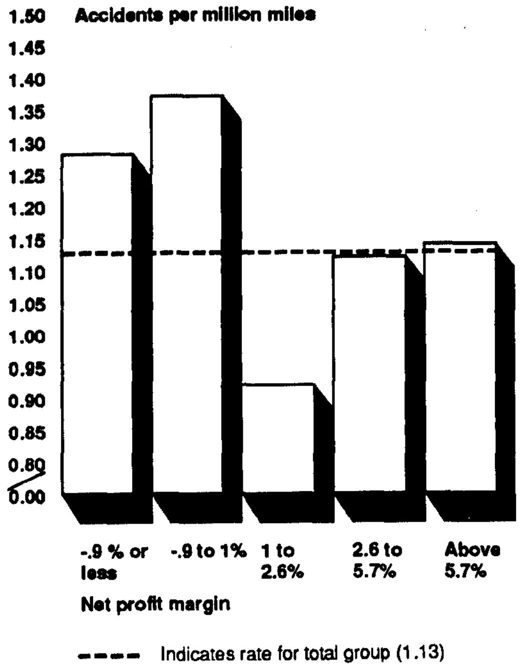
This curvilinear pattern is illustrated by the relationship between accident rates and return on equity, shown in figure 4.2. (Higher returns generally are assumed to reflect a healthier financial position.) The most striking finding is that carriers with the worst financial performance, losses of 0.3 percent or more on equity, had as a group by far the worst safety record two years later. Their group accident rate was about 27 percent (1.44/1.13) above the rate for all carriers (represented by the dotted line). Accident rates then substantially dropped with increasing returns, but rose again almost to the level of the overall rate in the two highest categories. (Similar curvilinear patterns were found for the related profitability measures of return on capital and return on transportation investment, as shown in appendix IV.)

Figure 4.2: Group Accident Rates, by Return on Equity



Another type of profitability measure, net profit margin, is net income divided by gross freight revenues. (A higher net profit margin generally indicates a stronger financial position.) As shown in figure 4.3, this profitability measure also exhibited a curvilinear relation with accident rates. Here, the two least profitable groups, showing low net profits or losses, had the highest accident rates, which were 13 percent (1.28/1.13) and 21 percent (1.37/1.13) above the total group rate. Those carriers with modest net profits had the lowest group accident rate, whereas the carriers with the highest profitability had somewhat higher group accident rates, which were close to the rate for all the carriers.

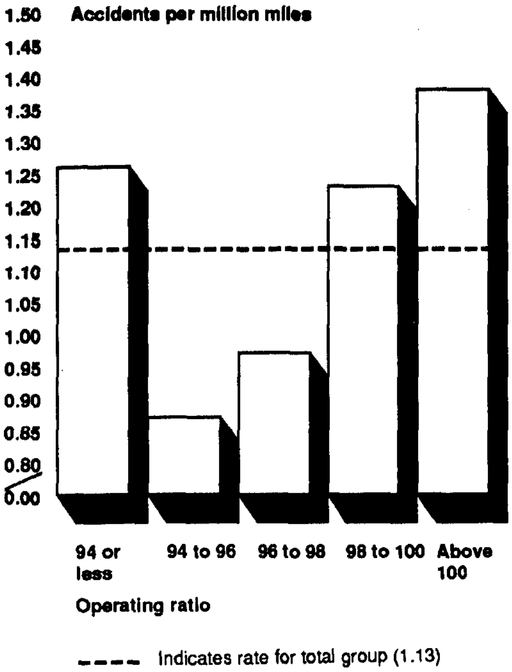
Figure 4.3: Group Accident Rates, by Net Profit Margin



The operating ratio, the last measure of profitability discussed here, is calculated as a carrier's operating expenses divided by revenues. Expressed as a percentage, an operating ratio of 100 means that a carrier's revenues are just meeting its expenses. Above 100, the carrier's expenses exceed its revenues. Below 100, the carrier's revenues surpass its expenses, and thus a lower operating ratio indicates a more favorable financial position.

As indicated in figure 4.4, the relationship of operating ratio to accident rates again showed a curvilinear pattern, with the least profitable carriers having the highest group accident rate. (The pattern in the figure is reversed in comparison to those for the other profitability measures because higher values of operating ratio reflect lower profits.) The least profitable carriers, those with operating ratios above 100, had the highest group accident rate, exceeding the overall group accident rate by 22 percent (1.38/1.13). However, those carriers with the most favorable operating ratios (94 or less) also exceeded the overall group accident rate, but by only 12 percent (1.26/1.13).

Figure 4.4: Group Accident Rates, by Operating Ratio



In sum, regardless of how profitability was measured here, the least profitable firms had the highest group accident rate two years later. This result is consistent with the hypothesis underlying our model, that economically weak firms are likely to engage in actions that, over time, result in a deterioration in safety outcomes. However, the most profitable firms also had somewhat elevated group accident rates relative to those for carriers with intermediate levels of profits. This was not anticipated by the model and suggests that extremes in profitability may be predictive of higher safety risks.

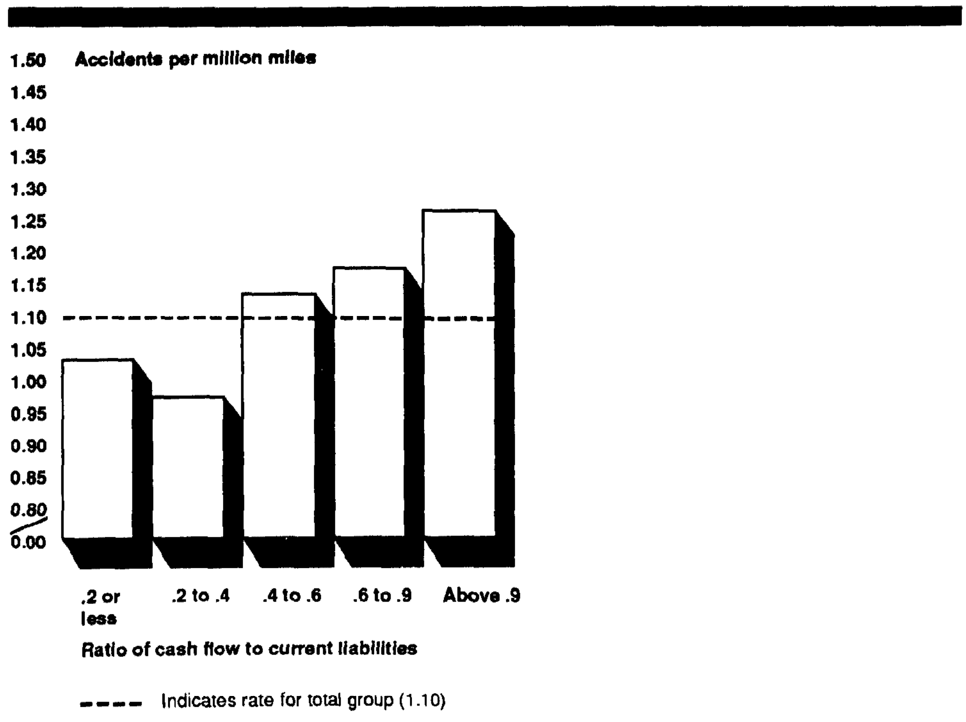
Cash Flow Ratio

Cash flow is a liquidity measure that indicates the ability of a carrier to pay its current debts. Firms with a higher ratio of cash flow to current liabilities have greater cash resources to meet their financial obligations. In contrast, less liquid carriers have a greater risk of bankruptcy due to an inability to repay creditors.

In comparison with the pattern shown with return on equity, we found somewhat weaker identification of high accident rates across categories of cash flow ratio. (See figure 4.5.) The highest category here, comprised of those carriers with a ratio above 0.9, exceeds the total group rate by 15 percent (1.26/1.10). The pattern is again relatively simple with regard to the total accident rate, but in the opposite direction compared to the profitability ratios discussed previously. Those carriers with low cash flow ratios have below average accident rates, and those carriers with higher ratios have progressively higher above-average rates.

This finding is inconsistent with the hypothesis that poor financial performance predicts subsequent poor safety performance. We do not have an explanation of why the relationship contrasts with those found with the profitability measures. Perhaps this liquidity measure is differentiating operating characteristics of carriers in a different fashion than do the profitability measures. In developing more complex financial predictors in the future, it may be useful to construct financial profiles of carriers combining both types of financial measures, since each type may be capturing different safety-relevant factors about carriers.

Figure 4.5: Group Accident Rates, by Ratio of Cash Flow to Current Liabilities

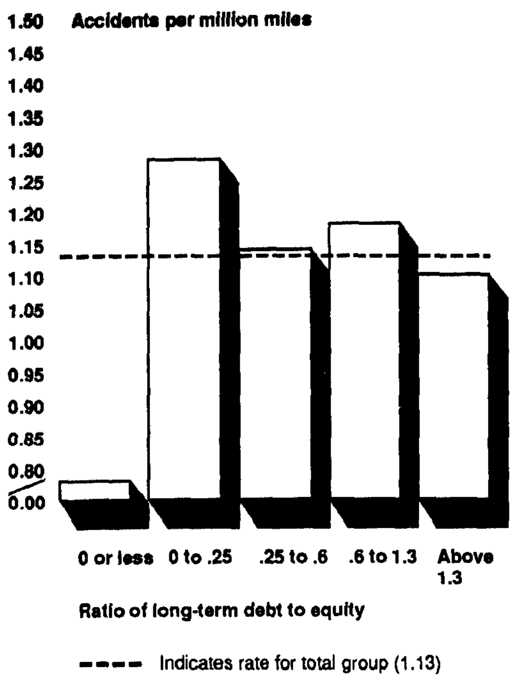


Long-Term-Debt Ratio

The long-term-debt ratio is measured as total long-term debt divided by equity. It is a leverage measure that indicates the extent to which a carrier uses debt to finance its assets. High debt ratios could indicate financial problems in that debt holders have a claim on the firm's earnings, which can lead to profitability and liquidity problems. To meet debt obligations, a firm might be forced to cut back on expenses in other areas, including those related to safety.

Perhaps the most striking point shown in figure 4.6 is that the ratio identifies a very low risk group. Carriers with no long-term debt or with debt owed them have an extremely low accident-risk rate, equaling 69 percent of that of the total group accident rate. In contrast, carriers with modest long-term debt have about a 13 percent (1.28/1.13) higher than average risk. Carriers with higher long-term-debt ratios do not substantially diverge from average risks.

Figure 4.6: Group Accident Rates, by Ratio of Long-Term Debt to Equity



Summary

In sum, our analysis suggests the promise of predicting categories of accident risk based on prior financial condition (although this conclusion is necessarily tentative given the inadequacies of existing data). For our sample of carriers, we identified seven financial ratios that distinguished higher and lower risks in a relatively simple pattern. Among these ratios, four profitability measures were the strongest predictors of higher accident risks 2 years later. Level of return on equity, return on transportation investment, operating ratio, and net profit margin allowed the identification of some carrier groups with accident rates of 21 to 27 percent above the total group accident rate. Return on capital, cash flow, and the ratio of long-term debt to equity revealed carriers with group accident rates 13 to 17 percent above the total group, and thus showed somewhat less strength in distinguishing higher accident risks. However, the ratio of long-term debt to equity does appear to distinguish a group of carriers with substantially lower than average safety risks.

Our findings, with some exceptions, are consistent with the premise that carriers with poorer financial positions pose greater safety risks. Five of the seven financial predictors showed patterns of safety outcomes in agreement with the underlying premise of the model discussed in chapter 2. For all of the profitability ratios—the operating ratio, net profit margin, and the three return ratios—those groups of carriers with the least favorable financial positions had the highest group accident rates. (However, carriers with the highest profitability ratios tended to have higher accident rates than carriers with more moderate profitability rates, which suggests that high as well as low profitability may be associated with higher risks.) A sixth predictor, the long-term-debt ratio, provided mixed evidence. Carriers with the apparently favorable position of no long-term debt had exceptionally low group risk; however, among carriers with debt, those with modest debt ratios had a higher group accident rate than did those with greater debt ratios. The seventh predictor, the cash flow to current liabilities ratio, appeared to contradict the premise in that carriers with cash flows that approximately equaled their liabilities had the greater accident risks.

The "U-shaped" patterns evident in the figures suggest that our hypothesis could be refined to recognize that both extremes in economic performance are associated with safety hazards. One plausible explanation is that a carrier may pay less attention to safety if it is either short of money or short of time. A carrier facing weak demand for its services may reduce safety efforts because it is short of money; a carrier facing strong demand for its services may reduce attention to safety because it is short of time.

Regardless of whether further research by DOT or others confirm that this refinement to our model is warranted, the potential use of the predictors remains unchanged. After our findings are validated or modified, groups of carriers with higher safety risks could be targeted for increased enforcement efforts. The degree to which the carrier groups exceed average safety risks, and other factors, might be weighted and used for targeting increased enforcement efforts. For example, our preliminary findings suggest a highest weighting factor score for the least profitable carriers, a next highest score for the most profitable carriers, and a lowest score for carriers of intermediate profitability.

Firm Size, Industry Segment, and Operating Style as Predictors of Safety Outcomes

In addition to financial measures, we also considered a number of economic-related factors that could be used to predict safety outcomes. Previous studies have suggested that firms that differ in size, operate in different markets, or have different ownership patterns may perform quite differently on safety outcomes. Since these data may be easier to collect than financial ratios, they could prove useful for safety monitoring purposes in the absence of financial information. In this section, we examine whether carrier size, industry segment, and owner-operator style of operation are associated with safety risks.

Carrier Size

As shown in the last column of table 4.2, the smallest carriers had the highest group accident rate, exceeding that of the largest carriers by 20 percent (1.37 - 1.14/1.14).[4] The table also shows that larger carriers were involved in the majority of accidents reported in the safety audits; however, they also had much greater accident exposure in terms of the number of miles their trucks were driven on the highways. The largest firms (those operating over 10 million miles annually) accounted for 80 percent of the 9,732 accidents and about the same proportion of the 8,549 million miles driven by all of the carriers in our analysis.

[4]We also examined the number of trucks operated by each firm as a measure of carrier size. However, this measure of size proved to be a less powerful predictor of safety risk than carrier size measured as annual mileage, which we report here.

Table 4.2: Accident Rates, by Size of Carrier

Annual miles driven (in millions)	Cases	Total accidents	Total miles (in millions)	Group accident rate
Below 2.5	186	332	243	1.37
2.5 - 5.0	120	541	438	1.23
5.0 - 10.0	118	1,102	885	1.24
Above 10.0	179	7,757	6,982	1.11
Total	**603**	**9,732**	**8,549**	**1.14**

From a safety enforcement standpoint, it is important to note that the individual accident rates of these smaller firms are less reliable than those of the larger carriers because the measurement of accident risks is unstable for carriers operating over a relatively low number of miles. (See our discussion in appendix III.) As a consequence, we cannot use accident rates to identify individual high-risk carriers, with certainty, from among the smallest carriers.

Moreover, despite the fact that these smaller carriers tend to have higher accident rates, enforcement efforts focused on the larger carriers with poor accident rates would appear to offer the greatest opportunity for reducing the total number of accidents. For example, if among the largest carriers the accident rates of the 18 carriers whose rates rank in the 90th or above percentile were reduced to the level of the 75th percentile, accidents would drop by 5 percent. This would reduce the total number of accidents by 507, which substantially exceeds the maximum possible reduction of 332 accidents resulting from the unlikely event that the accident rates of all 186 of the smallest carriers were reduced to zero.[5]

Industry Segments

Another economic factor that might be related to safety risk is the segment of the trucking industry in which the firm operates. As shown in table 4.3, the truckload (TL) carriers had a higher incidence of accidents than less-than-truckload (LTL) carriers. However, TL carriers of general freight had a markedly higher group accident rate than those of either TL carriers of specialized freight or LTL carriers. In fact, TL general

[5]Our analysis does not attempt to estimate what proportion of accidents are preventable. Certain risk factors, such as type of highways driven or traffic congestion, are likely to be largely outside the control of individual carriers. Moreover, since some carriers may be more exposed to risk factors outside their control, these carriers may be less able to take steps to reduce their accident rates. Thus, the accident risk posed by a carrier includes factors that are, to varying degrees, in or out of its—or for that matter, the government's—control.

freight carriers had a group accident rate that exceeded that of the total sample of carriers by 13 percent (1.28 - 1.13/1.13).

Table 4.3: Accident Rates, by Type of Truckload

Type of truckload	Cases	Total accidents	Total miles (in millions)	Group accident rate
TL general freight	145	2,925	2,291	1.28
TL specialized freight	340	3,973	3,520	1.13
LTL general freight	105	2,747	2,689	1.02
Total	**590**	**9,645**	**8,501**	**1.13**

Carriers that operated national or interregional routes had somewhat higher accident rates than those operating shorter routes. (We have defined carriers with average hauls of less than 500 miles as regional carriers, carriers with average hauls of 500 to 750 miles as interregional carriers, and carriers with average hauls of over 750 miles as national carriers.) Table 4.4 indicates that interregional carriers had the highest group accident rate, about 9 percent (1.23 -1.13/1.13) higher than that of the total sample of carriers.

Table 4.4: Accident Rates, by Length of Average Haul

Average haul (in miles)	Cases	Total accidents	Total miles (in millions)	Group accident rate
1 to 250	257	2,371	2,181	1.09
250 to 500	128	1,889	1,724	1.10
500 to 750	46	1,645	1,342	1.23
Above 750	92	3,311	2,879	1.15
Total	**523**	**9,216**	**8,126**	**1.13**

Style of Operation

One style of operation is for a carrier to hire its own employees and buy its own equipment. A contrasting style of operation is to lease equipment and/or drivers. (Both may be simultaneously leased by using the services of owner-operators who drive their own trucks.) We call the former the owner style of operation and the latter (which relies on purchased transportation to move freight) the broker style of operation. As shown in table 4.5, the styles form a continuum. For example, about a third of the carriers we studied reported using no owner-operators, whereas about a fourth reported using owner-operators to drive more than 60 percent of their total miles (which place them closer to the broker end of the continuum).

Table 4.5: Accident Rates, by Style of Operation

Indicators of degree of broker style	Cases	Total accidents	Total miles (in millions)	Group accident rate
Ratio of purchased transportation to revenues				
0 - 0.1	187	3,062	2,712	1.13
0.1 - 0.5	225	3,229	3,317	0.97
Above 0.5	167	3,355	2,426	1.38
Total	**579**	**9,646**	**8,455**	**1.14**
Percent of miles driven by owner-operators				
0	181	1,676	1,479	1.13
0 - 10	80	1,925	1,914	1.01
10 - 60	158	2,878	2,656	1.08
Above 60	148	3,011	2,316	1.30
Total	**567**	**9,490**	**8,365**	**1.13**

Among this sample of carriers, those carriers whose operations approximated the broker style had accident rates 15 to 21 percent above the rate for the total group. As measured either by purchased transportation or miles driven by owner-operators, the same curvilinear pattern appeared. Those companies closest to the owner style of operation had about an average group accident rate; those companies intermediate between the two styles of operation had a lower than average group accident rate; and those companies closest to the broker style of operation had a higher than average group accident rate. The contrasts were relatively strong. The strongest contrast was between the intermediate category and broker style (whose accident rate was 42 percent higher) as classified by the ratio of purchased transportation to operating revenues.

Conclusions

Our findings suggest that prior financial information shows promise for predicting which carriers have higher accident risks. Given the limitations on our data, however, we could not confirm whether the relations we found hold for the trucking industry as a whole and for time periods other than the early 1980's (when the industry faced a recession and a transition to economic deregulation). Moreover, because we had accident data for carriers at only a single point in time, we were unable to demonstrate prediction in the sense that changes in firms' financial conditions were accompanied by changes in accident rates.

To the extent that financial ratios reflect conditions in the various separate trucking industry markets, predictors based on these related factors might be as useful as, and more readily available than, financial information. Our findings on carrier size, industry segment, and operating style suggest that these predictors are almost as good as the financial ratios for strongly distinguishing risk pools. The strongest market-segment factors (size of carrier and ratio of purchased transportation) revealed groups of carriers with accident rates 20 and 21 percent above the total group's rate; the best financial ratios revealed comparable rates of 21 to 27 percent. Again, however, data limitations prevented us from testing whether these relations hold for the whole industry and for time periods other than the early 1980's. Moreover, these factors are probably more stable attributes of carriers than economic performance, and thus may be less useful for predicting emerging safety problems.

Given the lack of continuous information on all carriers, safety enforcement officials must necessarily prioritize their resources for monitoring and enforcement efforts. Many criteria reasonably could go into deciding these priorities. For instance, carriers of hazardous materials might receive special attention because of the severity of possible consequences, while carriers receiving an unsatisfactory rating on DOT's review of their safety-related management practices might also receive special attention because they are thought to pose higher safety risks.

Our findings focus on accident rates, and this is an important criterion for prioritizing the efforts of safety enforcement officials. In the last chapter, we discussed the data gaps that hinder the monitoring of accident rates across the industry, as well as the identification of the strongest predictors of higher accident rates. Here, we highlight the monitoring and accident prevention implications of our findings on financial and related measures.

First, our findings suggest that DOT safety officials can potentially use indicators of the financial health of firms to anticipate safety problems. DOT could coordinate with ICC and the Bureau of the Census to obtain the information needed to track economic trends in the trucking industry as a whole, as well as in the various segments of the industry, to measure financial trends that could indicate potential deterioration in safety outcomes. Our analyses illustrate the type of work that DOT could do.

Second, our findings highlight the importance of designing monitoring and prevention strategies geared to the differences among carriers. For example, to the extent that our findings reflect the situation in the trucking industry, safety enforcement officials apparently face the following situation in regard to size of carrier. The safety performance of the largest carriers is of most concern since they are involved in the majority of truck accidents; moreover, targeting the largest carriers with the highest accident rates may offer the greatest opportunity to prevent a sizable proportion of total accidents. However, as a group, small carriers pose a greater safety risk, and thus a higher proportion of the accidents from among this group may be preventable through monitoring and enforcement.

Findings Based on Two Submodels: Driver Quality and Regulatory Compliance

The model that we postulated hypothesizes that economic and other conditions can adversely affect truck safety through the cumulative impact of a variety of intermediate factors. Our results on this cumulative impact are generally consistent with this hypothesis and suggest that some of the measures we examined are sufficiently predictive of safety risk to allow DOT to develop them for the purpose of targeting priorities. (See chapter 4.) In this chapter, we examine two sets of these intermediate factors—that is, the two submodels that extant data allowed us to test.

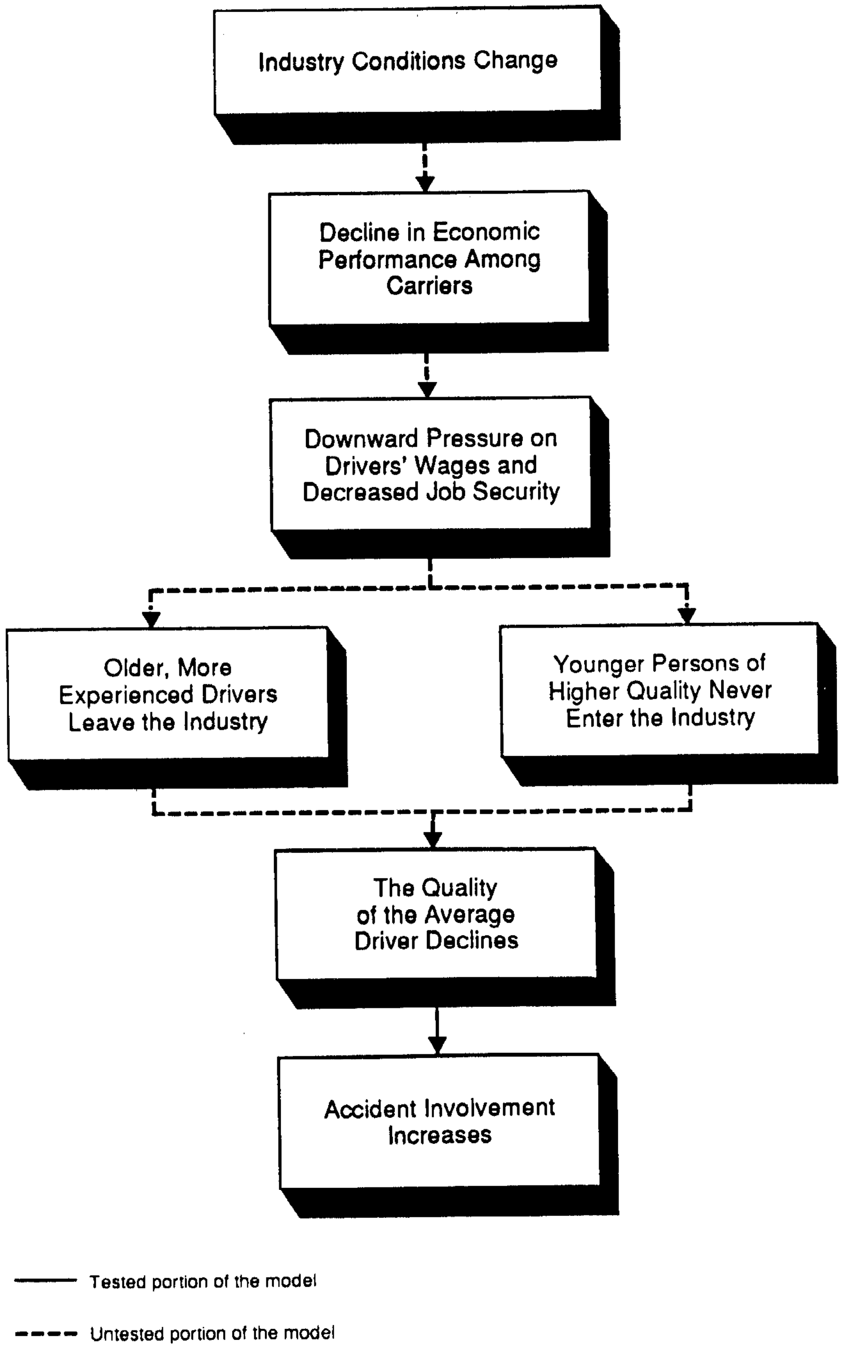
According to the driver quality and compliance submodels, if economic or other conditions in the industry should lead to a poorer quality of drivers or more pressure toward noncompliance with safety regulations, then truck accidents will increase. With the data available to us, we were unable to link these intermediate factors with economic conditions; however, we were able to test whether these intermediate factors are related to safety outcomes for some portions of the trucking industry.

The Driver Quality Submodel

The driver quality submodel links worsening safety outcomes to economic pressures on carriers. According to this submodel, if economic conditions in the trucking industry deteriorated, then carriers' restricted financial resources would place a downward pressure on wages and lessen job security through carriers' reducing their number of employees or exiting the industry. In turn, if lower wages and less job security made working in the industry less attractive, then the industry would be less able to retain and attract high quality drivers. To the extent that the proportions of younger, less experienced, or less capable drivers expanded, more accidents would be expected to occur.

Ideally, the driver quality submodel would be tested with economic data on company finances, driver compensation, diverse measures of driver quality, and accident data for a nationally representative sample of U.S. truck drivers over several years of their driving experience. Given the data available to us, we can test a modest but important portion of this submodel. (The portion of the submodel tested is represented by the solid line in figure 5.1.) We obtained access to tabular data on several relevant variables from a single year of a privately conducted survey of truck drivers. Based on these data, we analyzed the relationship between two presumed indicators of driver quality commonly used by industry analysts—driver age and length of driving experience—as well as accident involvement in the prior 12 months.

Figure 5.1: Driver Quality Submodel



The Regular Common Carrier Conference's Motor Carrier Safety Survey, conducted annually since 1986, focuses on drivers of long-haul, combination (towing one or more trailers) trucks serving the state of Florida.[1] Although the sample is not nationally representative (since the survey is limited to trucks serving Florida), the surveyed drivers come from states across the nation, as well as from Canada. Our data come from the approximately 1,300 drivers responding to the 1989 survey.

Our findings, based on the Florida survey, are generally consistent with the portion of the driver quality submodel that we could test—that is, younger and less experienced drivers were more likely to be involved in accidents.[2] Based on a statistical procedure known as loglinear analysis, we found that younger drivers were more likely than older drivers to be in accidents within the previous 12 months.[3] The loglinear procedure first estimates a statistical model that best fits the data on accident involvement for each group in the analysis, then uses that model as the estimate of the number of drivers in each group that could be expected to be involved in an accident. Next, the procedure allows us to calculate the odds that a given member of each group would be involved in an accident, based on the expected number of accidents for each group. (See appendix V for a fuller explanation of this procedure.)

The analysis of driver's age is shown in table 5.1. (Note that the expected accident counts can represent fractional drivers.) The loglinear model projects that the odds of being involved in an accident within the last 12 months were 0.135 to 1 for the youngest group of drivers, those 21 to 39 years old. This means that 135 of these drivers experienced an accident for every 1000 that were accident free for those 12 months. The odds of having an accident for the next older age group dropped to

[1]The Regular Common Carrier Conference (RCCC) contracts Dr. Richard Beilock, Associate Professor of Food and Resource Economics at the University of Florida, to carry out the survey. We appreciate the cooperation of RCCC and the efforts of Dr. Beilock in providing us with data from the survey.

[2]We would have liked to control for mileage so that the likelihood of accident involvement would not be interpretable as a function of exposure to possible accidents. For example, it is possible that the younger and less experienced drivers drove more miles per year and thus had greater exposure to possible accidents. Although the Florida survey collected data on drivers' mileage, we did not have it available for our analysis. In our analyses of the compliance model, however, we found that younger and less experienced drivers were more likely to violate speeding laws and hours of service regulations compared to other drivers who were driving the same miles annually. It is thus possible that age and years of experience are independently associated with the likelihood of accident involvement, regardless of miles driven per year.

[3]Loglinear analysis provides a statistical criterion for whether a relationship exists between two or more variables. It also provides a statistical model of this relationship that is as simple as possible and fits the observed data. This statistical model provides estimates of the size of the relationship between two variables, such as driver's age and accident involvement.

105 for each 1,000 accident-free drivers, while the odds for the oldest age category dropped again to 82 for each 1,000 accident free-drivers.

Table 5.1: Relationship Between Driver's Age and Accidents in Prior 12 Months

	Accident[a]		Odds on	Odds
Driver's age	Yes	No	yes:no	ratio
21 to 39	72.82	541.18	0.135	
				1.28
40 to 49	36.37	345.63	0.105	
				1.28
50 and older	21.82	265.18	0.082	

[a]The expected number of accidents as estimated by our statistical model

The relationships between these odds can be summarized by the odds ratio. Compared to drivers aged 40 to 49, drivers in the age range of 21 to 39 years have greater odds of accident involvement by a factor of 1.28. Compared to those for drivers over 50 years of age, the odds of the youngest group of drivers having an accident are greater by a factor of about 1.6 (1.28 x 1.28).

We similarly found accident involvement to be more likely among drivers with fewer years of truck driving experience. As shown in table 5.2, the simplest loglinear model that adequately fits the data shows a decreasing likelihood of accidents as years of driving experience increase. (The odds and odds ratios for the three categories of experience are almost identical to those reported previously for the three categories of age, which probably reflects the fact that younger drivers tend to be less experienced.) The odds ratio indicates that those drivers with 13 or fewer years of driving experience had greater odds of accident involvement than those with 14 to 20 years experience, by a factor of about 1.27. Compared to those drivers with more than 20 years experience, those in the category of fewest years of experience had greater odds of accident involvement by a factor of about 1.6.

Table 5.2: Relationship Between Years of Driving Experience and Accidents in Prior 12 Months

	Accident[a]		Odds on	Odds
Years of driving experience	Yes	No	yes:no	ratio
0 to 13	77.64	585.36	0.133	
				1.27
14 to 20	26.72	255.28	0.105	
				1.27
21 and more	25.64	310.36	0.083	

[a]The expected number of accidents as estimated by our statistical model

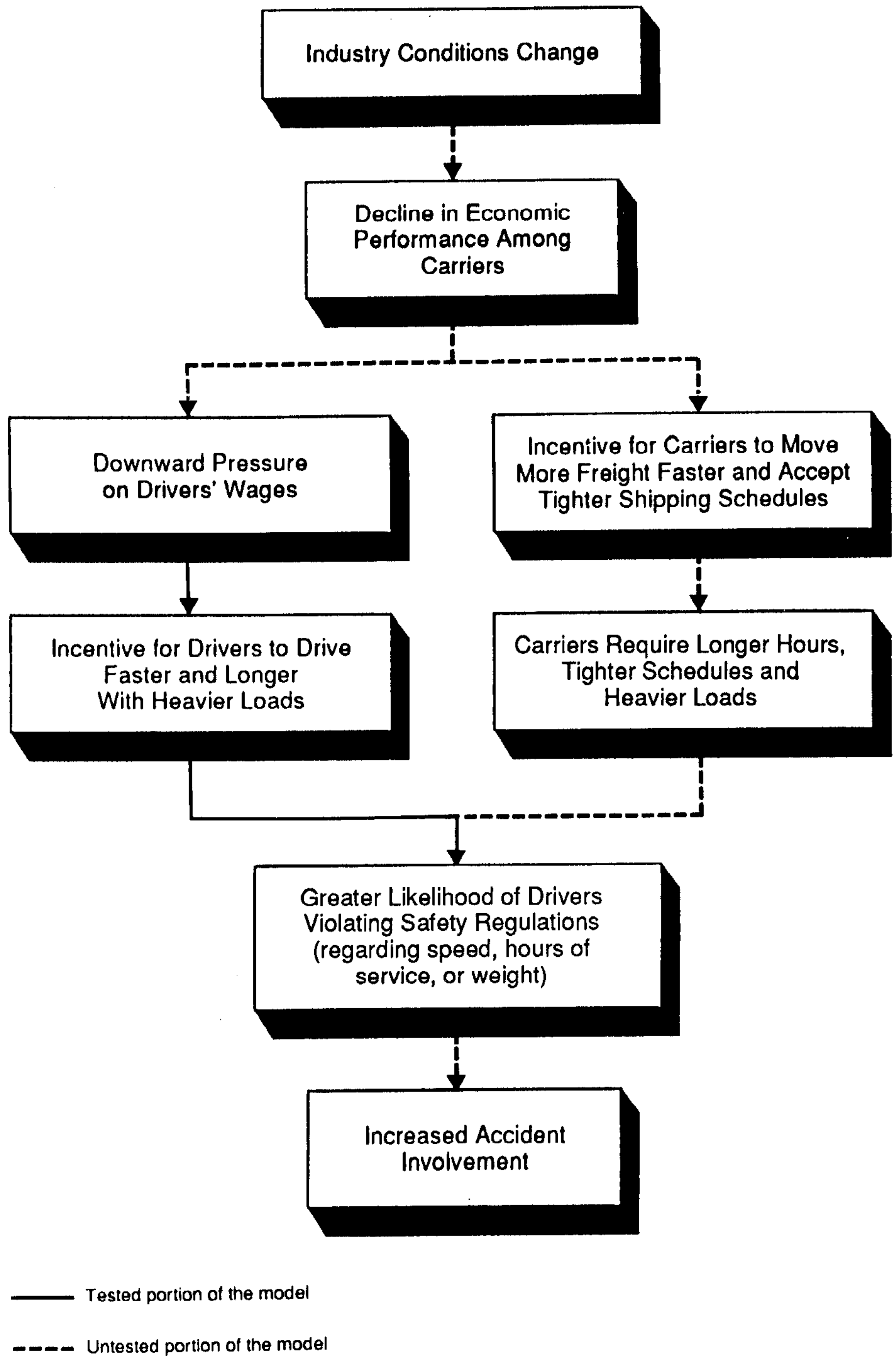
Although our findings are generally in agreement with the driver quality submodel, our test relied on rather broad groupings of the youngest and least experienced driver categories. Grouping drivers to include those between 30 and 39 years old or those with as many as 13 years of truck driving experience may not fit the common image of young and inexperienced drivers. However, we could not distinguish, with statistical confidence, between drivers aged 21 to 29 and those aged 30 to 39, or between those with 0 to 6.5 years of experience and those with 7 to 13.5 years, on the basis of their likelihood of having been involved in an accident. The inability to statistically distinguish between these groups could result from technical constraints, such as sample size, but the observed data did not indicate a stronger relationship among younger and less experienced drivers.

The Compliance Submodel

The compliance submodel indicates a chain of associations among carrier finances, modes and levels of driver compensation, driver compliance with regulations, and safety outcomes. If economic conditions create financial strains within carriers, then a downward pressure occurs on drivers' compensation. In the face of the slowing growth of, or decline in, rates of pay (per mile or per load), the submodel postulates that drivers have an incentive to maintain their earnings by driving faster and longer than allowed by regulation. It further assumes that any actual noncompliance with regulations increases the risk of accidents.

As with the driver quality submodel, we gained access to tabular data from a privately conducted survey of truck drivers that allowed us to test a portion of this submodel. This survey--whose data are known as the National Motor Transportation Data Base (NMTDB)—provided relevant information on driver compensation, citations in the prior 90 days, and driving time on the interview day. Although these data did not allow us to test the links between noncompliance and carrier finances or accidents, they did allow us to examine the association between wage levels and noncompliance with regulations. The portion of the submodel that we studied is indicated by the solid line in figure 5.2, but note that we examined the level of drivers' wages, rather than changes in them, because we had data for only a single year. This approach only indirectly tested the model, employing the assumption that lower wages for drivers reflect a financial situation similar to that created by a loss in real wages.

Figure 5.2: Driver Compliance Submodel



NMTDB is a nationwide annual sample of rail-competitive trucking gathered since 1977. In 1988, the year for which we were provided tabular data, NMTDB included over 25,000 interviews with truck drivers conducted at 21 locations across the United States.[4] Thus, although the NMTDB is not nationally representative of all trucks, it does represent a large national sample of truck drivers from the rail-competitive market.[5] The sample is composed of drivers of combination trucks that are primarily engaged in long haul, truckload (TL) operations.

Our evidence is consistent with the submodel's hypothesis concerning drivers' wages and compliance, but only for company drivers and not for owner-operators. Among company drivers, those earning less per mile were more likely to violate speeding laws and have hours-of-service violations. In contrast, the wage level of owner-operators appeared to have no effect on hours-of-service violations and had a complex relationship with speeding citations that is not fully congruent with the compliance submodel.

Measures in Our Analyses

Our separate analyses of owner-operators and company drivers resulted from both theoretical considerations and necessity. This separation is useful because owner-operators' behavior may differ from that of company drivers as a result of differences in how they are paid. (Owner-operators are often paid on a percentage of revenue basis rather than on a per mile or load basis.) It is also necessary because the NMTDB data does not allow for calculating the wages of these two types of drivers in the same manner. The company drivers' compensation is calculable as cents per mile, whereas the owner-operator drivers' compensation is calculable as gross annual revenue per mile.

We focused on two types of driver noncompliance—violations of speeding laws and hours-of-service regulations—that the submodel predicts will have an impact on the likelihood of accidents. The driver's self-report of a citation or warning for speeding in the past 90 days was used as the measure of speeding noncompliance. For noncompliance

[4]The Association of American Railroads provided us with tabular data from this survey, which was conducted by Transportation Research and Marketing.

[5]Since the sample analyzed by us was not randomly selected, our findings are limited to our sample. It was focused on drivers in the most rail-competitive trucks—those with dry van, refrigerated, or flatbed trailers—and excluded drivers reporting unusual operating statistics, such as under 25,000 miles driven annually. Trucks with team drivers were also excluded because of different requirements for hours of service. Drivers who reported citations—except those for brake, vehicle condition, logbook, or speeding violations—were also excluded.

with hours-of-service rules, we used two alternative measures. The first measure was a logbook citation or warning in the prior 90 days, which we assumed to reflect primarily hours-of-service violations (rather than technical violations such as failure to maintain the logbook).[6] The second measure of noncompliance with hours-of-service rules was derived by adding the hours truckers reported having driven on a particular day to the additional hours they expected to drive that same day. If the total hours for the day exceeded the maximum of 10 hours allowed by regulation before a mandatory 8-hour rest period (although we used 11 hours as the criterion to allow for some overestimation of the duration of the remaining trip), we assumed an apparent violation of hours-of-service regulations.[7] We limited all analyses to solo drivers because team drivers (less than 15 percent of the sample) could drive more than 10 consecutive hours without violating hours-of-service regulations.

Our Analyses

We found that hours-of-service violations among these drivers may be widespread and largely undetected. In our sample, as many as 29 percent of owner-operators and 31 percent of company drivers could have been violating hours-of-service regulations during the day of their interview (since they had been driving more than 11 hours). However, only slightly more than 2 percent had received a citation/warning for logbook violations during the previous 90 days.

Next, we examined whether driver compensation was associated with speeding or hours-of-service violations. With regard to noncompliance with speeding laws, we found a rather simple pattern among company drivers. Compared to the odds of drivers making 18.5 or more cents per mile reporting speeding violations in the prior 90 days, the odds for less-well-paid company drivers were about twice as large. (See table 5.3.) Our analysis suggests a threshold related to compensation: Whereas in the six highest wage categories (18.5 or more cents per mile) 8 to 11 percent of drivers reported receiving speeding citations, 16 percent of

[6]Our analysis assumes that the likelihood of receiving a citation/warning directly reflects, though likely underestimates, the actual prevalence of violations. We are thus assuming that each driver violating speeding or hours-of-service regulations was equally likely to be detected and receive citations/warnings.

[7]This measure may underestimate or overestimate the frequency of noncompliance with hours of service regulations. On the one hand, it may underestimate the amount of noncompliance because (1) it allows an additional hour before assuming noncompliance, (2) drivers may not have started the day after the mandatory 8-hour rest period, or (3) drivers may underestimate the actual duration of their remaining driving hours for the day. On the other hand, it may overestimate noncompliance if drivers overestimate the duration of the remaining driving hours or if they schedule an 8-hour rest period after 10 hours of service.

drivers earning less than 18.5 cents reported speeding citations.[8] This finding is consistent with the assumption of the compliance submodel in that drivers who earn less, and thus are presumably under a stronger incentive not to comply with regulations, were more likely to violate speeding laws.

Table 5.3: Relationship Between Company Drivers' Compensation and Speeding Citations or Warnings in Prior 90 Days

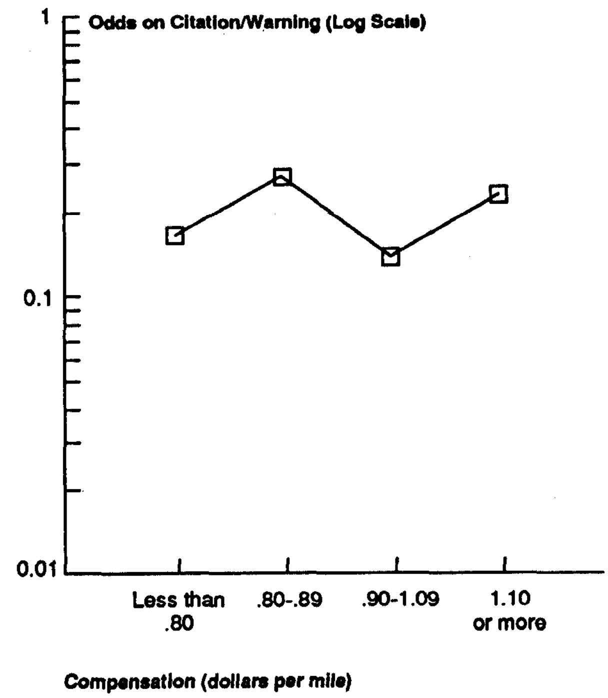
Compensation (cents per mile)	Speeding citation or warning[a] Yes	No	Odds on yes:no	Odds ratio
Less than 18.5	92	499	0.184	
				0.55
18.5 and more	608	5,985	0.102	

[a]The expected number of citations or warning as estimated by our statistical model

In contrast to the simple pattern of differences in speeding citations among company drivers, we found a more complex pattern among the owner-operator drivers than would be expected based on the compliance submodel—that is, the expectation that lower compensation would lead to greater noncompliance. Although owner-operator drivers at different levels of compensation have statistically different likelihoods of receiving speeding citations, those drivers with the lowest compensation do not have the highest expected odds of noncompliance, nor do those with the highest level of compensation have the lowest expected odds of noncompliance, as the submodel would predict. (See figure 5.3.) Instead, the intermediate levels of compensation have both the highest and the lowest expected odds of noncompliance.

[8]We began our analysis with 10 compensation categories in cents per mile: less than 14, 14 to less than 15.5, 15.5 to less than 17, 17 to less than 18.5, 18.5 to less than 20, 20 to less than 21.5, 21.5 to less than 23, 23 to less than 24.5, 24.5 to less than 26, 26 or more. For company drivers, we found we could collapse down to two compensation categories without any significant loss of information. However, the small number of drivers in the very lowest wage categories (below 18.5 cents per mile) limited our ability to distinguish significant differences in noncompliance among these low wage categories or to contrast them individually with higher wage categories.

Figure 5.3: Odds of Receiving Speeding Citations/Warnings Among Owner-Operator Drivers, by Compensation



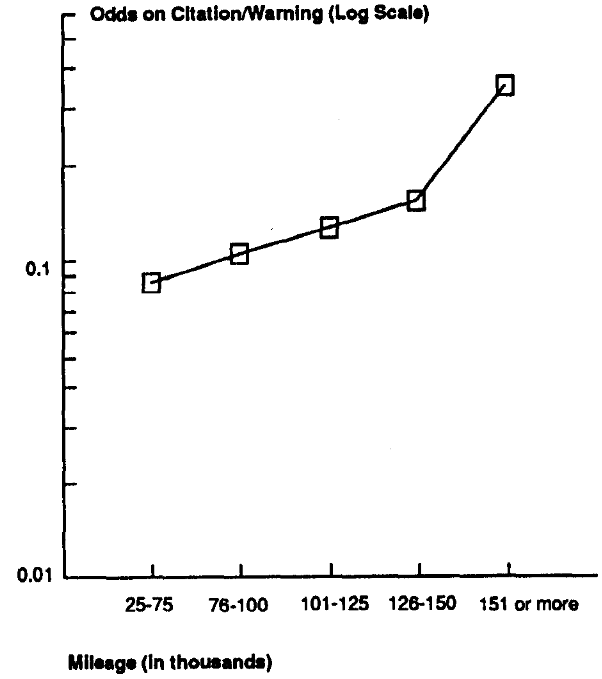
Note: The odds are estimated by our statistical model.

We cannot explain this unusual pattern in the findings. It could possibly indicate that wage differentials among owner-operators reflect qualitative differences (in kind of carrier, driver, or some other dimension) rather than simply quantitative differences in wages. We are unable to examine these possibilities with the tabular data available to us.

We had expected that the likelihood of receiving a speeding citation would be affected by both the amount of exposure the driver had to detection and the frequency of speeding behavior. As expected, we found that drivers who drove more miles were more likely to receive speeding citations. Two points about this relationship, shown in figure 5.4, are important. First, the relationship is best modeled as a linear trend up to 150,000 miles per year. At this point, the likelihood of a speeding citation jumps sharply. This jump may reflect the necessity of speeding in order to cover so many miles in a year. For example, a driver who worked 50 hours a week for 50 weeks a year would need to average 60 miles per hour to achieve a total of 150,000 miles in a year;

to reach 175,000 miles, the same driver would need to average 70 miles per hour.

Figure 5.4: Odds of Receiving Speeding Citations/Warnings, by Annual Mileage



Note: The odds are estimated by our statistical model.

Second, our analyses indicated that the relationship between compensation and speeding (as well as logbook) citations is unaffected by the number of annual miles driven, and this is true for both owner-operators and company drivers. This means that, regardless of the number of annual miles driven, the less-well-paid company drivers had the same greater likelihood of receiving speeding citations as other company drivers driving a similar number of annual miles. The effect of annual miles and compensation were thus additive; a less-well-paid company driver had a higher likelihood of speeding citations than other company drivers, and this likelihood became even higher as this driver covered more miles in a year.

Our findings about hours-of-service violations likewise are congruent with the compliance submodel—but again, only for company drivers. (Compensation among owner-operators was not associated with the likelihood of receiving a logbook citation.) As shown in table 5.4, the odds of higher paid company drivers having received logbook citations in the prior 90 days were about half those of lower paid company drivers. A similar pattern appears in our analysis of apparent hours-of-service violations (over 11 hours in the surveyed trip). The odds of an apparent violation generally declined with increased compensation, as shown in table 5.5, although drivers earning between 18.5 and 19.9 cents per mile had higher odds than would be expected based on the generally linear trend among drivers in other earnings categories.

Table 5.4: Relationship Between Company Drivers' Compensation and Logbook Citations or Warnings in Prior 90 Days

Compensation (cents per mile)	Logbook citation or warning[a]: Yes	No	Odds on yes:no	Odds ratio
Less than 18.5	24	567	0.042	
				0.51
18.5 and more	139	6,454	0.022	

[a]The expected number of citations or warnings as estimated by our statistical models

Table 5.5: Relationship Between Company Drivers' Compensation and Apparent Hours-Of-Service Violations

Compensation (cents per mile)	Apparent hours-of-service violations[a]: Yes[b]	No	Odds on yes:no	Odds ratio
Less than 17	29.46	52.54	0.561	
				0.93
17 to 18.4	174.19	334.81	0.520	
				1.16
18.5 to 19.9	342.00	567.00	0.603	
				0.74
20 to 21.4	806.68	1,801.32	0.448	
				0.93
21.5 to 24.4	605.54	1,457.46	0.415	
				0.93
Greater than 24.4	282.12	731.88	0.385	

[a]Drivers reporting trips exceeding 11 hours a day are classified as apparently violating hours-of-service regulations.

[b]The expected number of violations as estimated by our statistical model

Conclusion

Our analyses have tested portions of two predictive submodels of safety-related outcomes and have provided evidence consistent with the assumptions of both of these submodels. As anticipated by the driver-quality submodel, we found evidence that indicators of driver quality among drivers serving Florida were related to the likelihood of accidents. The youngest group of drivers and the least experienced group of drivers were more likely, by a factor of 1.6, to have accident involvement than, respectively, the oldest group of drivers and the most experienced group of drivers. We also found indirect support for the compliance submodel among company drivers in the rail-competitive market. Company drivers who earned less per mile were more likely to violate speeding laws and hours-of-service regulations.

From a policy perspective, the submodels provide an avenue for identifying indicators that could warn of potential safety problems. Identifying these indicators could allow more selective allocation of monitoring and enforcement efforts toward the types of carriers or drivers associated with higher accident or noncompliance risk. Further, if these indicators allowed for prediction of higher safety risks over time, tracing trends in these indicators could alert safety enforcement officials to intensifying safety problems and thus enable them to plan ameliorative actions.

Although our partial confirmation of the driver quality and compliance submodels raises the hope that such policy-relevant indicators can be constructed, further work by DOT is needed before this hope can be realized.

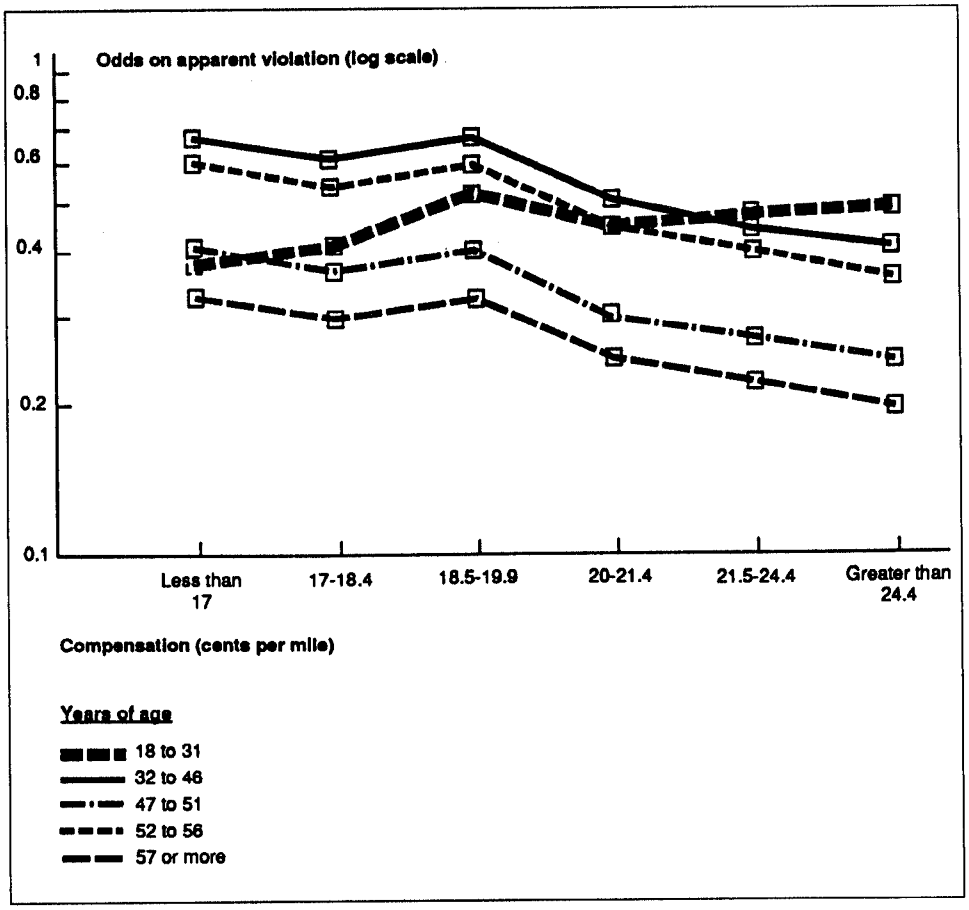
First, since our analysis has been limited to testing for relationships between the intermediate variables and safety outcomes, the task of identifying economic or other predictors of the intermediate variables remains. At present, federal data to pursue this task are not available. The critical barrier to advancing this pursuit of predictive measures is a lack of the type of data that measure the economic and intermediate factors, as well as accident rates, for a definable portion of the industry.

Second, further analysis is needed to show that the predictors are robust under a variety of conditions and that changes in the predictors indicate future changes in safety outcomes. Our analysis is static in that it is limited to a single year and does not look at change measures. It needs to be replicated in other years to confirm that the intermediate variables as we have defined them are predictors under a variety of conditions. Further, we have demonstrated associations and not causal links between these intermediate factors and safety outcomes. It is necessary to test whether changes in the average age, experience, and compensation of drivers lead to changes in safety outcomes as predicted by the submodels.

Third, the model and its submodels appear to require more specificity. For instance, the driver quality and compliance submodels, and the variables underlying them, may interact in a complex fashion, and this may require further specification in order to use the submodels for predictive purposes. Our analyses have focused on testing the submodels separately, but it should not be assumed that a profile of the higher-accident-rate driver can be derived simply by listing characteristics from the two submodels. For example, the relationship between age and compensation, on the one hand, and apparent hours-of-service violations, on the other, does not appear to be simply additive. As shown in figure 5.5, the odds of apparent hours-of-service violations generally declined with increased levels of compensation for company drivers in most age groups, although not for those younger than 32. For this youngest group, the odds of apparent violations slightly increased, rather than decreased, with higher levels of compensation. Thus, the compliance model's assumption that lower compensation creates pressure for noncompliance may only hold for some types of drivers.[9]

[9]The reason for the age-related difference reported here is not clear; however, younger drivers may find higher rather than lower compensation a greater incentive for noncompliance, or perhaps they tend to drive for the type of carrier that has both tighter schedules and better pay.

Figure 5.5: Odds of Encountering Apparent Hours-Of-Service Violations Among Company Drivers, by Age Group and Compensation



Note: The odds are estimated by our statistical model.

Thus, although a model can usefully simplify a complex reality, the driver quality and compliance submodels seem to require a somewhat more complex or less global formulation in order to aid policy and enforcement ends. In addition to the interactions between the submodels, further work is needed on the types of drivers or industry segments to which the submodels apply. For instance, our analysis showed a relationship between compensation and logbook citations for company drivers, but not for owner-operator drivers. Moreover, for predictive purposes, we would want to know how well the models will hold for other types of drivers and industry segments—that is, those not represented in the samples we analyzed.

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Federal Data Sets on the Economics of the Freight-Trucking Industry

In this section, we describe two federal collections of economic information on the trucking industry and consider their usefulness for the purpose of developing preventive measures or monitoring trends in the trucking industry.

ICC Financial Reports

ICC financial reports offer a broad range of detailed information about the financial health of individual carriers. Reporting carriers submit a balance sheet of financial assets and liabilities, as well as an income statement. Although requirements are not uniform for all types of carriers, carriers submit operating statistics such as intercity tonnage and mileage.

For our purposes, the advantage in the breadth and depth of ICC financial information is lessened by the scope of data collection. ICC only requires financial data from the largest of carriers (those with annual revenues exceeding $1 million), which results in its collecting information on only a small percentage of ICC-regulated carriers. For example, in 1988, only 5 percent of ICC-regulated carriers fell into the classes of carriers required to provide financial data.

Moreover, ICC financial data cannot be generalized to the whole trucking industry because exempt, intrastate, and local carriers in the for-hire sector, as well as all carriers in the private sector, are not represented in this data. Despite these important limitations, ICC data provide an opportunity to follow trends in the financial health of some of the largest for-hire interstate carriers. (In 1988, the carriers in these reporting classes generated about 82 percent of the estimated $65 billion in transportation revenues attributable to ICC-regulated carriers.)

For the objective of developing preventive measures, the major drawback of ICC data is the lack of accident data. Many federal accident data sets—Fatal Accident Reporting System (FARS), National Accident Sampling System (NASS), GES, CARDfile, and TIUS—are not organized by carriers, and thus cannot be combined with ICC data. However, Safety Review, Safety Audit, and Form 50-T data are organized by carrier, but only the Safety Audit data can be usefully merged with ICC data. Using Form 50-T accident data creates problems of interpretation because DOT officials estimate that carriers' underreporting may be as high as 40 percent.[1] The Safety Review tends to be targeted toward smaller carriers than its predecessor the Safety Audit. Thus, only the Safety Audit data are likely to have sufficient overlap between audited carriers and the large carriers reporting financial data to ICC.

While merging data from the Safety Audit and ICC's financial reports provides a unique opportunity to examine the relationships between economic factors and accident rates (see chapter 4), the resulting data have important limitations. First, since the Safety Audit was discontinued after 1986, analysis is limited to periods prior to 1987. Second, findings based on carriers found in both data sets are not generalizable to a definable portion of the trucking industry (although the carriers are limited to larger, for-hire, and interstate carriers operating under ICC authority).

Motor Freight Transportation and Warehouse Survey

The Motor Freight Transportation and Warehouse Survey (MFTWS), which is conducted by the Bureau of the Census, is an annual survey of firms primarily engaged in providing commercial motor freight transportation and warehousing services. The major strength of MFTWS is that it provides a representative picture, over time, of a sizable and definable portion of the trucking industry. Although the survey excludes private carriers and independent owner-operators, MFTWS provides annual national estimates for the remaining portion of the trucking industry.

The survey collects information from carriers on their operating revenues, operating expenses, and number of vehicles. It lacks the balance sheet information and operating statistics found in the ICC financial reports. Nevertheless, the operating ratio, a commonly used industry measure, is directly calculable for specialty freight carriers, general freight carriers, or all carriers.

The value of MFTWS for federal monitoring of economic trends or analysis, in combination with other accident data, is limited for two reasons. First, financial ratios that would require balance sheet or operating statistics (for example, return on assets or revenue per ton) are unavailable from this source. Second, and most important, the sampling error around the survey's estimates limits meaningful analysis. For example,

[1] This problem of unreliability represents a particularly serious loss of information for safety research because the 50-T reports are DOT's only attempt to collect annual, comprehensive, and nationwide statistics covering all types of accidents (fatalities, injuries, and property damage) experienced by interstate motor carriers.

the range of estimates for the 1988 operating ratio for all covered carriers (at a low 67-percent level of significance) would be approximately 87 to 104, a range far too wide to statistically detect meaningful industry trends.

Sample of Interstate Carriers and Measures

In chapter 4, we analyze whether financial performance and other market-related factors are associated with accident rates. Here we describe the carriers in our sample and the measures we used. In particular, we explain the measurement issue that led us to analyze accident rates measured for groups of carriers rather than individual carriers.

Sample

The sample of carriers used for our analyses was drawn from those appearing in both the 1984-86 Safety Audits and the 1981-86 ICC financial reports. As discussed in appendix II, this sample is not representative of the industry; however, it provides a unique opportunity to bring the rich ICC financial data together with DOT safety risk data. We would have preferred to draw on more current data but had to use the latest information available from the Safety Audits, which were discontinued in October 1986. After excluding some carriers from the analyses, we had a total of 603 carriers in the sample.[1] The number of carriers in specific analyses is often fewer because of missing data items or calculation problems (for example, an undefinable division by zero in calculating a financial ratio). The maximum number of carriers for our financial ratios analyses, for example, was 537 because only these carriers in our sample provided financial data to ICC two years prior to the available accident data for them.

ICC has extensive financial data on trucking firms. However, since ICC generally regulates only for-hire interstate carriers, and only requires financial reporting from the largest of these, these data do not represent the industry as a whole. Thus, the carriers in our sample tend to be relatively large; about 54 percent operated more than 75 trucks, and under 10 percent operated fewer than 21 trucks. Using average hauls of 500 or fewer miles to define regional carriers, about 74 percent operated in regional rather than national markets. Approximately 80 percent of the firms in our sample were predominantly truckload (TL) rather than predominantly less-than-truckload (LTL) carriers. Among the TL carriers, about 30 percent carried general freight, and the rest specialized in some particular type of cargo. None of these carriers was among the new entrants that received ICC authorization after 1980.

[1]We excluded carriers that operated in clearly unique markets—for example, small package and household goods carriers—for which we had too few cases in our merged set of carriers to permit analysis. We also dropped cases from our analyses if the ICC financial data did not pass error-check procedures when it was entered into computer files. Finally, we excluded one case because the number of accidents was in the implausible range of over 17,000, suggesting an error in the data file.

One consequence of the sampling plan forced on us by the limited availability of needed data is that our findings may underestimate the degree to which economic factors affect safety risks. The sample underrepresents the industry segments believed by some researchers to pose the greatest safety risks. We might have found larger differences in safety risks if we had analyzed very small carriers or new entrants to the industry.

Group Accident Rates

Among other data, the Safety Audits gave us crucial information for accident rates—that is, each carrier's mileage and number of accidents in the 365 days prior to the audit. These two pieces of information were important because they allowed us to measure a key outcome specified in our safety model, accident rate. An accident rate can be calculated by dividing the number of accidents reported in the safety audit for the previous 365 days by the reported number of miles driven.

We have analyzed our data using group accident rates. Group accident rates are calculated by grouping carriers by size, financial health, or some other factor and then dividing the total number of accidents by the total number of miles driven for each category of carrier. We chose to use group accident rates rather than individual firms' accident rates because the latter are unreliable measures of accident risk for smaller firms.

We noted in chapter 4 that accident rates, measured as accidents per million miles, are unreliable measures of safety risk among small carriers. Since accidents are relatively rare events, carriers with low mileage tend to experience insufficient numbers of accidents relative to miles traveled to construct a reliable measure of their safety risk. This instability in measurement is partly evident in the fact that each single accident considerably affects the accident rate of a carrier with low mileage but only marginally changes the rate for a large carrier. Consider a hypothetical small carrier whose trucks are driven 500,000 miles in a year. If during the year a drunken automobile driver ran into one of its trucks, this carrier would have an accident rate of two accidents per million miles, placing it in the top quartile of firms in terms of its accident rate. If the chance accident was somehow avoided, this carrier would have an accident rate of zero.[2] In contrast, for a large carrier

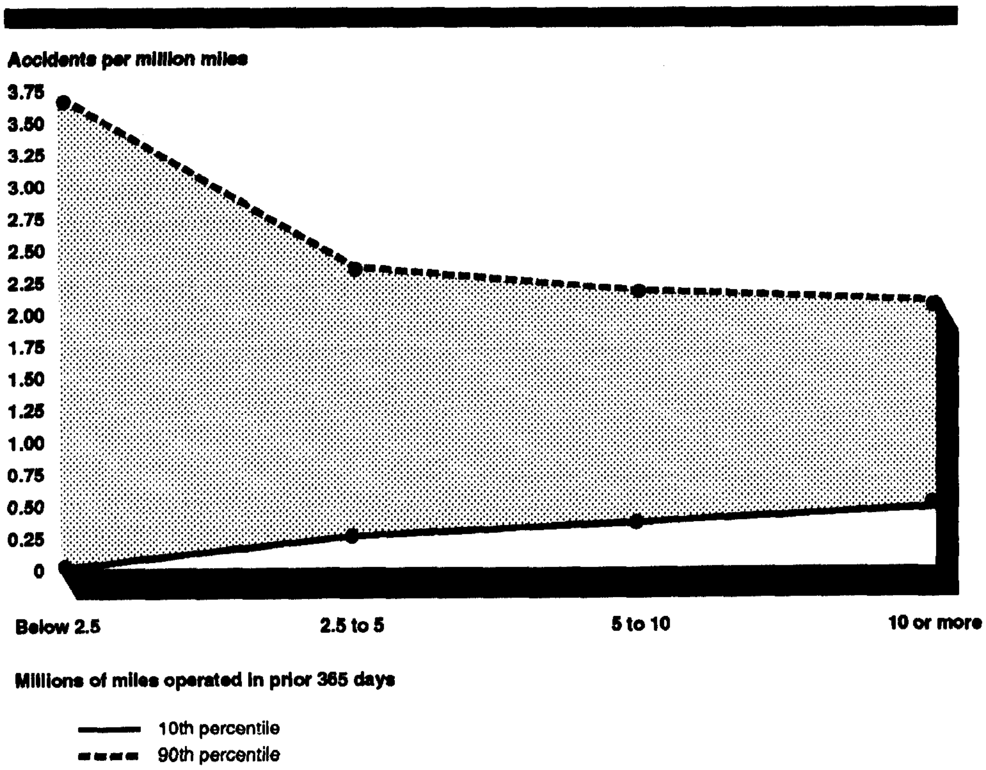
[2]Another reason why smaller carriers are more likely to have accident rates of zero is that DOT officials believe small carriers are less likely to report accidents. To the extent that this underreporting is not detected in the Safety Audits, the group accident rates will systematically underestimate the higher risks among smaller carriers.

whose trucks are driven 100 million miles annually and who already has 100 accidents, the single accident would minimally change its accident rate, from 1.00 to 1.01.

In the aggregate, this lesser reliability is manifested in the fact that the smallest carriers have more variability in their individual accident rates than do the larger carriers. The accident rates of smaller carriers are much more likely to fall at either extreme. About 40 percent of the smallest carriers rank in the top quartile of accident rates, whereas only about 13 percent of the largest carriers do. At the other extreme, one third of the smallest carriers have accident rates of zero, whereas not one of the largest carriers does.

This uneven variation in rates is displayed in figure III.1. The figure shows the range of scores between the 10th and 90th percentiles for four sizes of carriers. The horizontal funnel shape of these ranges indicates that the variation in accident rates is largest among the smallest carriers.

Figure III.1: Variation in Accident Rates, by Carrier Size



Any analysis based on the accident rates of individual small carriers risks confounding unreliable measures of safety risk with true variation in safety risk. For example, an analysis based on looking at the worst (or best) accident rates would disproportionately identify smaller firms, even though it is uncertain whether their higher (or lower) rates result from greater (or lesser) safety risks or less reliable measures. When we recognized that the rates were unstable for small carriers to the degree that chance could cast individual carriers to either end of the accident rate distribution, we decided against any conventional analysis based on the rates for individual carriers.[3]

The group accident rate, which we apply in our analysis in chapter 4, solves the problem of low mileage exposure among the small carriers by combining the mileage of all carriers in the groups. In effect, the group accident rate treats the small firms as a single firm that operates several million miles in a year, which provides a more stable basis to assess accident rates. As such, it indicates the average risk of the carriers in the group. This is not to deny that very different levels of risk actually exist among individual small carriers. Rather, we are simply recognizing our inability to reliably detect such differences.

Financial Measures

Our constructed data set provided a financial picture of each carrier for the period prior to that for which we had accident information. Since the accident data were not gathered for calendar years, we identified the closest fitting of three calendar years (1983-85) for each carrier's safety audit. We then linked to this accident data the annual ICC financial data for 2 years earlier. In other words, if we had accident data on a carrier for 1985, we drew annual ICC financial data, if available, for 1983.

From the ICC data, we constructed measures of a number of economic and related factors as possible predictors of safety outcomes in the industry. These factors included market-related indicators such as firm size, industry segment, and ownership pattern. In addition, we considered a wide variety of financial ratios, 13 in all. The variables we considered as predictors of accident rates are used routinely by those

[3]Other types of regression based on categories (such as one based on a Poisson distribution) may be appropriate for this type of analysis to test for significant differences and trends. We chose a descriptive approach to the data because the sample was not random and thus findings from any type of analysis would not be generalizable to the trucking industry.

involved in the trucking industry to describe ICC carriers.[4] We used the respondent rather than consolidated ICC data for our analysis because they correspond to the "for-hire" activity for which we examined safety outcomes.

The formulas of the financial ratios are outlined in table III.1. Note that the financial ratios cannot meaningfully be calculated in some circumstances. We did not calculate the ratios if data were missing for any items or if the denominator was zero (since division by zero is not possible) or negative (since interpreting a positive or negative ratio then becomes ambiguous or not meaningful). For example, return on negative equity does not lend itself to a meaningful interpretation, and a negative return on a negative equity becomes a (misleading) positive ratio. Moreover, we only calculated ratios with negative numerators if the resulting negative ratios would be meaningful—which is the case for net profit margin, return on transportation investment, return on equity, return on capital, long-term debt to equity, net debt to equity, and cash flow to current liability. Also, if the denominator was a small number, the financial ratio became less stable, as indicated by extremely large ratios, and thus likely less interpretable as extreme financial success. We did calculate ratios regardless of the size of the denominator, and this may mean that the highest level in our financial categories contained more error than the other levels.

[4]The financial ratios are operating ratio, net profit margin, return on transportation investment, return on equity, return on capital, current ratio, turnover of net carrier operating property, long-term and net debt to equity, cash flow to current liabilities, and accounts receivable turnover. The two operating ratios are revenue per mile and per ton. We did not use several other ratios—average day's expenses in working capital, number of times interest earned, revenue per shipment, weight per shipment, and revenue per ton-mile—because they could not be calculated for 20 percent or more of the sample. All of these ratios appear in the Motor Carrier Annual Report, published by the American Trucking Associations.

Table III.1: Formulas for Financial Ratios

Financial ratio	Formula
Operating ratio	Total operating expenses divided by total operating revenue, times 100
Net profit margin	Total other income or deduction divided by total operating revenue, times 100
Return on transportation property investment	Ordinary income after taxes divided by the sum of net carrier operating plus total current assets minus total current liabilities, times 100
Return on equity	Ordinary income after taxes divided by the sum of total stockholder's equity plus sole proprietor or partner equity, times 100
Return on capital	Ordinary income after taxes divided by the sum of total stockholder's equity plus sole proprietor or partner equity plus total long-term debt, times 100
Current ratio	Total current assets divided by total current liabilities
Turnover of net carrier operating property	Total operating revenue divided by net carrier operating property
Long-term debt to equity	Total long-term debt divided by the sum of total stockholder's equity plus sole proprietor or partner equity
Net debt to equity	The sum of total long-term debt plus total current liabilities minus total current assets divided by the sum of total stockholder's equity plus sole proprietor or partner equity
Cash flow to current total liabilities	The sum of net income or loss plus depreciation and amortization minus provision for deferred taxes minus equity in earnings or losses for affiliates divided by total current liabilities
Average day's expenses in working capital	The sum of total current assets minus total current liabilities divided by the sum of total operating expenses minus total depreciation and amortization minus net disposition of operating assets, divided by 365
Accounts receivable turnover	Total operating revenue divided by other notes and accounts receivable (net of allowance for uncollectible accounts)
Number of times interest earned	The sum of income from continuing operations plus interest or amortization, debt discount expense, and premium, divided by interest or amortization, debt discount expense, and premium
Revenue per mile	Freight revenue divided by total highway miles operated
Revenue per ton	Freight revenue divided by total tons carried in intercity service

Appendix IV

Data on Financial Ratios and Accident Rates

Table IV.1 presents the data underlying our analysis of financial ratios and accident risks that is presented in chapter 4. In addition, we present a similar analysis for a more complex financial ratio in a second table. (See page xx.) The data for all financial ratios in these analyses were gathered from a period approximately 2 years prior to the period covered by the accident data.

Table IV.1: Group Accident Rates, by Financial Ratios

Financial ratio	Cases	Total accidents	Total miles (in millions)	Group accident rate
Revenue per mile				
1.00 or less	83	1,572	1,087	1.45
1.00 to 1.20	107	2,255	2,174	1.04
1.20 to 1.60	117	1,520	1,153	1.32
1.60 to 2.50	103	1,614	1,812	0.89
Above 2.50	101	1,908	1,698	1.12
Total	**511**	**8,869**	**7,924**	**1.12**
Operating ratio				
94% or less	114	1,746	1,388	1.26
94 to 96	91	1,376	1,590	0.87
96 to 98	106	1,814	1,874	0.97
98 to 100	111	2,444	1,991	1.23
Above 100	115	1,757	1,274	1.38
Total	**537**	**9,137**	**8,117**	**1.13**
Long-term debt to equity				
0 or less	83	699	899	0.78
0 to 0.25	129	2,065	1,611	1.28
0.25 to 0.6	92	1,549	1,353	1.14
0.6 to 1.30	101	2,309	1,964	1.18
Above 1.30	99	2,144	1,947	1.10
Total	**504**	**8,766**	**7,775**	**1.13**
Return on equity				
-3% or less	100	2,110	1,466	1.44
-3 to 7	102	2,069	1,954	1.06
7 to 14	98	1,313	1,388	0.95
14 to 26	99	1,586	1,446	1.10
Above 26	101	1,673	1,510	1.11
Total	**500**	**8,751**	**7,764**	**1.13**

(continued)

Financial ratio	Cases	Total accidents	Total miles (in millions)	Group accident rate
Net profit margin				
-0.9% or less	109	2,153	1,676	1.28
-0.9 to 1.0	106	1,647	1,204	1.37
1.0 to 2.6	107	2,555	2,774	0.92
2.6 to 5.7	109	1,381	1,238	1.12
Above 5.7	106	1,401	1,225	1.14
Total	**537**	**9,137**	**8,117**	**1.13**
Return on capital				
-2.8% or less	104	1,622	1,233	1.32
-2.8 to 4.0	103	2,744	2,257	1.22
4.0 to 9.0	106	1,813	2,041	0.89
9.0 to 17.5	106	1,387	1,233	1.13
Above 17.5	104	1,530	1,320	1.16
Total	**523**	**9,096**	**8,083**	**1.13**
Turnover of net carrier operating property				
3.5% or less	107	2,564	2,400	1.07
3.5 to 5.0	99	1,709	1,407	1.21
5.0 to 7.0	106	1,641	1,766	0.93
7.0 to 12.5	108	1,648	1,211	1.36
Above 12.5	107	1,444	1,242	1.16
Total	**527**	**9,006**	**8,027**	**1.12**
Return on transportation investment				
-2.7% or less	100	1,707	1,268	1.35
-2.7 to 4.8	103	2,975	2,899	1.03
4.8 to 10.0	101	1,709	1,577	1.08
10.0 to 18.0	100	1,059	930	1.14
Above 18.0	106	1,557	1,335	1.17
Total	**510**	**9,007**	**8,010**	**1.12**
Revenue per ton				
17 or less	99	653	546	1.20
17 to 32	99	1,261	1,174	1.07
32 to 52	96	1,415	1,164	1.22
52 to 86	101	2,284	1,763	1.29
Above 86	95	3,087	3,142	0.98
Total	**490**	**8,700**	**7,788**	**1.12**

(continued)

Financial ratio	Cases	Total accidents	Total miles (in millions)	Group accident rate
Net debt to equity				
-0.3 or less	114	1,509	1,189	1.27
-0.3 to 0	90	1,278	1,330	0.96
0 to 0.5	107	2,492	2,129	1.17
0.5 to 1.5	91	1,662	1,528	1.09
Above 1.5	98	1,810	1,587	1.14
Total	**500**	**8,751**	**7,764**	**1.13**
Cash flow to current liabilities				
0.2 or less	89	1,404	1,363	1.03
0.2 to 0.4	104	1,721	1,780	0.97
0.4 to 0.6	119	2,636	2,329	1.13
0.6 to 0.9	80	1,269	1,084	1.17
Above 0.9	97	1,418	1,130	1.26
Total	**489**	**8,448**	**7,687**	**1.10**
Current ratio				
0.8 or less	114	1,492	1,550	0.96
0.8 to 1	70	1,426	1,233	1.16
1.0 to 1.4	134	2,452	1,971	1.24
1.4 to 2.1	110	2,208	2,076	1.06
Above 2.1	106	1,546	1,277	1.21
Total	**534**	**9,124**	**8,108**	**1.13**
Accounts receivable turnover				
9 or less	100	1,415	1,361	1.04
9 to 12	129	2,163	1,683	1.29
12 to 14	85	1,504	1,378	1.09
14 to 18	106	2,893	2,720	1.06
Above 18	114	1,161	974	1.19
Total	**534**	**9,136**	**8,116**	**1.13**

It could be argued that single financial measures are not adequate measures of financial health and that several financial ratios must be considered in order to have a balanced assessment of any carrier's financial picture. One such measure of financial distress, the C-score model (which is based on weighted scores from various financial ratios), has been developed to predict bankruptcy among motor carriers. The C-supermodel version of the C-score is calculated based on five weighted ratios: (1) cash flow to equity, (2) ordinary after-tax income to total tangible assets, (3) current assets to total tangible assets, (4) total liabilities to total tangible assets, and (5) retained earnings to total tangible assets. (For further discussion of the C-score model, see Garland Chow and Richard Gritta, "Estimating Bankruptcy Risks Facing Class I and II Motor Carriers: An Industry-Specific Approach," Transportation Practitioners Journal, 55:4 (Summer 1988), pp. 352-63.)

However, when we analyzed this more complex measure of financial health, we found that it did not differentiate accident rates as strongly as did some of the single financial ratios. See table IV.2. (Lower scores are interpreted to mean higher financial distress and greater likelihood for bankruptcy.)

Table IV.2: Group Accident Rates, by C-Score

C-score	Cases	Total accidents	Total miles (in millions)	Group accident rate
-0.2 or less	102	1,631	1,505	1.08
-0.2 to 0.2	96	2,646	2,321	1.14
0.2 to 5	96	1,365	1,194	1.14
0.5 to 0.9	102	1,949	1,675	1.16
Above 0.9	104	1,160	1,068	1.09
Total	**500**	**8,751**	**7,764**	**1.13**

Driver Characteristics and Safety Risks: Loglinear Analyses

For our analyses of the driver quality and driver compliance submodels in chapter 4, we applied a statistical technique known as loglinear analysis. In this appendix, we explain loglinear analysis and why we chose this type of analysis.

Loglinear Analysis

We chose loglinear analysis as the appropriate statistical technique to examine the association between driver characteristics and safety risks for two reasons. First, our data came from two proprietary surveys in tabular form (that is, with dimensions, such as compensation, divided into categories), and loglinear analysis is an appropriate technique for analyzing categorical data. Second, compared to conventional regression techniques, loglinear analysis is better for analyzing discrete outcomes that are relatively rare events (such as accident/no accident or citation/no citation).

Loglinear analysis provides a statistical means for identifying the simplest model that fits a set of observed data. We were able to use it to discern relationships between variables that might otherwise be obscured by fluctuations in the observed data because of sampling error or other instabilities.

We applied loglinear analysis in the following fashion. First, we constructed a number of models, ranging from simple to complex. (The simplest model always assumes that there is no relationship between the predictor variables and the outcome variable.) Using statistical tests, we then compared each of the models to the actual data obtained in our sample to see if the frequencies expected under the model and the actual observed data differed significantly. If they did not significantly differ (meaning that the model "fit" the data), we kept that model in contention for our choice of most preferred model. After doing a series of tests on successive models, we chose the simplest one that fit the data and could not be improved upon by adding more complex relationships.

The preferred model provides estimates of the magnitude and direction of the relationships. These estimates are based on the expected frequencies in the preferred model and can be expressed as odds and odds ratios. Odds indicate the tendency of a given subgroup of the population, as defined by one variable in the analysis, to assume one value of a second variable rather than another. If the expected frequencies were that 150 young drivers would have accidents and 1,000 young drivers would not, then the odds on young drivers having an accident would be .15 (150/1000).[1]

Different subgroups can be compared by an odds ratio, which consists of the odds of one group divided by the odds of another. If there are no significant differences between the two groups, their odds are equal, and the odds ratio between them is 1.0. The greater the divergence of the odds ratio from unity, the larger the magnitude of the effect. For example, if older drivers had odds of 0.075 of being in an accident and younger drivers had odds of 0.15, then the odds ratio between these groups would be 2 (0.15/0.075)—which indicates that the odds of younger drivers experiencing accidents are twice as large as those for older drivers. This would illustrate a relatively large divergence from unity and a sizable relationship between age of driver and accidents.[2]

[1] Readers with less familiarity with odds than with proportions or percentages may find some clarification useful. Odds are related to proportions (p) in the following manner: odds = p/(1.0 - p). Thus, a proportion of 75/100 (or percentage of 0.75) is equal to an odds of (0.75/(1.0 - 0.75))—that is, 75 to 25, or 3.

[2] The percentage of difference between these hypothetical accident rates of younger and older drivers would be quite small because accidents are relatively rare events. In part, that is why odds and odds ratios and the loglinear models that generate them are preferable to analyses based on percentages or proportions and the differences between them. While percentages or proportions are bounded top and bottom—which makes it difficult to see differences if they are very small or large ones—odds are not. (However, seeing differences in proportions may be helpful for assessing the substantive importance of findings.)

Comments From the Department of Transportation

Note: GAO comments appear at the end of this appendix.

U.S. Department of Transportation

Assistant Secretary for Administration

400 Seventh St., S.W. Washington, D.C. 20590

JAN - 3 1991

Ms. Eleanor Chelimsky
Assistant Comptroller General
Program Evaluation and
Methodology Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Ms. Chelimsky:

Enclosed are two copies of the Department of Transportation's comments concerning the U.S. General Accounting Office report entitled "Freight Trucking: Preliminary Evidence Shows That Carrier Financial Position, Size, and Other Factors Can Predict Safety Risks."

Thank you for the opportunity to review this report. If you have any questions concerning our reply, please call Martin Gertel on 366-5145.

Sincerely,

Paul T. Weiss
for Jon H. Seymour

Enclosures

Department of Transportation
Reply to GAO Draft Report of November 9, 1990, on
Freight Trucking: Preliminary Evidence Shows That Carrier
Financial Position, Size, & Other Factors Can Predict
Safety Risks

Summary of GAO Conclusions and Recommendations

The House Committee on Public Works and Transportation requested the GAO to determine whether certain economic or other conditions could be used as predictors of safety outcomes. The GAO's goals were:

(1) to formulate a predictive model specifying hypothetical relationships between safety and a set of conditions in the trucking industry;

(2) to assess the availability and quality of Federal data required to test the model; and

(3) to use available data, to the extent possible, to develop a set of indicators that would predict safety problems in the freight trucking industry.

The GAO believes its study demonstrates the feasibility of using indicators that relate to the economic health of carriers to predict safety problems in motor carrier firms, and recommends that the Secretary of Transportation direct the Federal Highway Administrator to require that mileage data be collected annually from motor carriers.

Summary of Department of Transportation Position

While the FHWA agrees that the GAO's hypothesis has potential validity, we cannot concur with the report because we believe the GAO's findings are not strong enough to warrant either the conclusion contained in the title of the report or the recommendation and inferences contained in the executive summary. This response reflects the Department's nonconcurrence.

POSITION STATEMENT

Study Findings Not Conclusive

The FHWA believes the GAO's hypothesis relating the financial position of a carrier to the safety of its operations has potential validity. However, the findings of this study are not strong enough to warrant either the conclusion contained in the title of the report or the recommendation and inferences contained in the executive summary. In fact, many disclaimers were inserted throughout the text which state that neither cause nor effect was proven. For example, on page 1-15:

Now page 17.

2

> We were able to use existing data to show whether certain economic or other factors were associated with safety outcomes and thus appear to be promising preventive indicators. Nevertheless, improved data and further analyses will be needed to validate the importance of these factors as prevention indicators and to develop others. [emphasis added]

Now page 15.

There is a strong implication that the carrier inspection program should be based on the predictive indicators. On page 1-10, the GAO stresses the usefulness of its model in a manner which goes far beyond these qualified conclusions:

> A model comprised of such prevention indicators would be of use in assessing the overall level of safety in the industry, and also could serve as a signalling mechanism for Congress and the relevant agencies as to what specific areas are most in need of attention...

It would be premature at this point to do more than take financial condition into consideration along with a host of other variables. The results of the study are not conclusive. To establish the relationship between safety and financial factors, measures of vehicle size, and driver characteristics requires further statistical analysis. The bimodal distributions resulting from the correlation analyses demonstrate that interpretation of the results is not straightforward.

Care should be exercised in all forms of financial ratio analysis for a number of reasons. Financial statement accounts may be subject to some degree of "window dressing." For example, the sale of assets just prior to the end of year closing may result in a more favorable cash position and liquidity ratio. Different accounting practices and conventions between companies may also result in distorted comparisons. Small firms, especially proprietorships, are a big problem, as "profits" may be paid as salaries to officers and their families. Comparative analysis is problematic when firms differ significantly in terms of their product lines, scope of services, scale of operations, and reporting by subsidiaries. It is axiomatic that the direct comparison between firms, and between firms and industry average values, requires appropriate levels of homogeneity. Furthermore, a single financial ratio may be subject to quite different qualitative interpretations. For example, high asset utilization ratios may indicate efficiency or, alternatively, undercapitalization. Use of financial ratios without stratification by industry segments has little explanatory power. Further, the distinctions between regional, national and local firms should be investigated to distinguish the effects of unique cost structures on safety risks.

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Methodologies that extend and enhance the use of financial ratios are available from a body of literature which deals with identification of variables which are good predictors. Multiple discriminate analysis has been used to distinguish between financially distressed and non-financially distressed carriers. In recent research, safety performance was compared among general freight carriers. In that study, "measures of safety performance were expenditures on safety, compliance with Federal safety regulations, and accident rates." (See Michael W. Blevins and Garland Chow, "Truck Safety and Financial Distress: A Preliminary Analysis," Journal of the Transportation Research Forum, Volume XXIX, Number 1, 1988, pages 18-23.) GAO should consider this approach.

Misleading Tone of the Comments

A main concern is that readers who read only the executive summary will be led to believe that the model does, in fact, link economic conditions with declining safety performance in the freight trucking industry. Readers who read the body of the report will find any such links to be much more ambiguous. For example, on page E-5, it is stated that, "carriers with losses of .3 percent or more on equity had a group accident rate... that was 27 percent above the total group's average," without noting that the carriers with average to high positive returns on equity had the next highest accident rates.

Now page 4.

Essentially, the "economic predictors" that are truly "economic" (for example, profit, cash flow, leverage of operating ratio) are unsatisfactory predictors either because they are ambiguous (profit, operating ratio) or counter-intuitive (cash flow ratio, long-term debt to equity). The "economic predictors" which show some promise (for example, carrier size, industry segments) are not so much "economic" as "operating characteristics," and should be identified as a separate set of predictors in the executive summary.

For these reasons, we suggest that the GAO carefully review the text and reword it in those areas where it might mislead the average reader into an impression that poor economic conditions are demonstrably and definitively linked with poor safety performance and that the Department of Transportation (DOT) can use economic indicators to identify high-risk carriers for safety enforcement purposes. For example:

Now page 2.

- The second paragraph of the background (page E-2) should be changed to "GAO developed a hypothetical model that attempts to link changes..." and "The hypothesis is that a decline..."

Now page 2.

- Results in Brief (page E-3) should begin "GAO's findings are very preliminary at this stage, but show that some

4

indicators in the general model might be able to be used to predict safety problems."

Now page 3.

o In the fourth and fifth sentences of Results in Brief (again on page E-3) make clear that "compensation" and "lower paid drivers" refer only to "company employee drivers," not owner operators. Move the last sentence regarding "most profitable carriers" (without the parentheses) to page E-5, after "27 percent above the total group's average."

Now page 4.

Deleted.

o In The Model (page E-4), change "would likely provide useful predictors" to "could conceivably provide."

Now page 4.

o In Economic Predictors (page E-5), explain that the GAO analysis does not apply to private carriers since none were examined (first paragraph).

The report includes speculations about possible relationships which are not supportable from the research literature. For example:

o Descriptions of unsafe practice are provided as background without providing measures of their extent as a means of putting the problems into perspective.

o Perceptions of owner-operators as less safe drivers are portrayed as fact and, even though these are acknowledged as "general belief which may not be reality," the assertion remains in the model.

o The linkage between truck size and weight and safety does not take into account the wide variations in safety among vehicle configurations. No recognition is made of the complexity of the issue which, combined with the lack of detailed data and analysis, makes objective factual information scarce.

Driver Quality and Compliance as Predictor

The Department is very much aware that accident data indicate a link between experience (and operator age) and truck accidents. Not surprisingly, some major insurance companies will not write policies for over-the-road drivers below the age of 25. Yet, at this point, with recent landmark DOT highway safety initiatives to improve operator proficiency still being implemented, we believe that it is premature to call for additional action until these efforts have been given a chance to work.

We are firmly convinced that the new Commercial Driver's License (CDL) regulations that require standardized written and oral examinations germane to the responsibilities of heavy truck operation, the elimination of multiple driver's licenses, and the establishment of the Commercial Driver's License Information System (CDLIS), will go a long way toward removing irresponsible and incompetent drivers from the roads. We expect that when these initiatives are fully implemented in about 2 years, a large number of drivers who fail to meet the new requirements, and, therefore, will not receive CDL's, will be younger, inexperienced ones. We also expect that the elimination of multiple licenses will hasten the removal of the most reckless of drivers of any age.

We believe that these initiatives need a chance to work. The CDLIS and SAFETYNET data systems will give us the capability to track developments with respect to age and experience of drivers and take further action as necessary.

Data Collection Recommendation to the Secretary

The study findings alone do not warrant imposition of the data collection requirement. Vehicle miles traveled, by carrier, was not shown to be the crucial missing piece of information which would make its collection "a first step toward reducing the accidents of interstate motor carriers..." The FHWA recognizes the need for better mileage information and has considered various approaches to obtaining it. However, the burden that would be imposed on carriers by a major, new Federal reporting requirement for the industry must be taken into consideration. The GAO makes no effort to quantify the cost of such a reporting requirement to private industry.

Some further considerations with regard to the mileage data are:

- o Mileage itself is a poor proxy for "exposure." As the GAO notes, various factors affect the degree of exposure, such as urban versus rural miles, interstate versus primary or secondary road miles, day versus night travel, etc. Given the fact that mileage is imperfect unless collected in several (perhaps numerous) stratifications, the GAO should consider estimating exposure by more easily known factors such as the number of power units and the type of operation (private versus for-hire is the most obvious) and using this with accident data to obtain an accident rate "index."

- o As the GAO points out, accident rate data (accidents per mile) for individual "small" carriers is statistically unreliable due to the low frequency of accidents.

The Department has supported legislation requiring all States to participate in base State systems for simplification of the vehicle registration and fuel tax reporting of interstate operations. Since carrier mileage would be reported under such a system as a means to apportion among the States the fees paid under such systems, the FHWA could potentially obtain mileage from these systems. It should be recognized, however, that mileage information will not be available in the near future. The GAO should modify its recommendation such that if mileage data becomes available from other sources, the FHWA should obtain it. Finally, the GAO report seems to recommend that the FHWA collect annual mileage data from all carriers, even non-interstate carriers. Since such carriers are not now subject to FHWA safety regulations, it is not clear that they would have to comply with the data requirement.

The lack of data (also a key factor pointed out in the report) has, in the past, greatly discouraged analyses such as those exemplified in the GAO report. With the better quality data now on hand (carrier reviews, inspections, and soon expected SAFETYNET accident data), the FHWA agrees that such analyses will be possible. However, the FHWA believes that, due to the complex and (still) incomplete nature of the data and untested models developed by GAO, the analyses should be:

- ongoing efforts both to allow familiarity with the sources and peculiarities of the data, and to thoroughly "mine" the data for the best relationships; and

- efforts specifically in support of the FHWA motor carrier safety policies and program directions. To be productive, such analyses must be closely tied to data currently available and to policies currently under consideration, such as the prioritizing requirements in the Educational and Technical Assistance and Selective Compliance and Enforcement programs, Safety Rating algorithms, and Motor Carrier Compliance Certification.

The Department agrees with the need for better indicators of truck safety problems. During fiscal year 1991, the FHWA will begin research to identify potential surrogates for truck exposure data and predictors of safety problems. The GAO report will provide a resource in this effort.

The following are GAO's comments on the Department of Transportation's letter dated January 3, 1991.

GAO Comments

Strength of the Model

FHWA, commenting on an earlier draft of this report, concluded that our "hypothesis relating the financial position of a carrier to the safety of its operations has potential validity" but objected that we overstated the strength of the findings of our study. We have changed the text to clarify our argument, which FHWA apparently did not fully understand. We assembled data sets that enabled us to conduct certain tests of the statistical relationship between financial (as well as certain other) characteristics of firms and carrier safety results. Those analyses show some striking relationships, which are generally consistent with the model we developed, suggesting that financial vulnerabilities of freight-trucking firms could be predictors of subsequent safety problems. These findings were sufficient to suggest to us that a relationship appears to exist between carrier financial position and safety outcomes. This in turn suggests the possibility that DOT may in the future be able to use data systems—if they are improved upon—to develop a validated safety monitoring system.

Although we agree with DOT that our model needs refinement, we otherwise assess our model very differently from the way DOT does. First, the agency's concern that "neither cause nor effect was proven" in our work does not constitute a limitation of the model because using a model as an early warning system of safety problems in the carrier industry requires that the model make good predictions rather than prove cause and effect. For example, economists use several "leading indicators" models to predict the occurrence and timing of economic slowdowns and recessions. These predictive models are useful to the extent that they predict slowdowns accurately, but they are not used to determine the "cause" of a slowdown or recession.

Second, the agency notes certain limitations of various financial indicators. However, it is not any intrinsic meaning of a measure that is relevant here; it is the extent to which the measure accurately predicts safety problems. Thus, for example, the agency's concern over interpreting high asset-utilization ratios is not necessarily germane. An indicator that a financial analyst finds flawed could still serve well in a predictive model.

Recommendation on Mileage Data

We are encouraged that DOT "agrees with the need for better indicators of truck safety problems" and will begin research in the area during this fiscal year. In chapter 3, we develop the argument that the availability of good mileage data, which would enable DOT to construct a safety enforcement model that includes accident rates, is crucial to a sound model. (We were only able to obtain mileage data for one time period and for those carriers that had been audited.)

DOT argues at some length against the idea that it should collect mileage data from carriers. It cites (1) the possible use of existing or future data sources, (2) the limited usefulness of mileage data without stratification by other exposure factors such as road type, and (3) the burden of data collection. We believe that DOT should reconsider each of these issues.

Although we agree that exposure data could potentially be collected in a variety of ways, we are concerned about DOT's proposed approaches. In proposing secondary sources of mileage data as they become available, DOT leaves open the possibility of a lengthy delay in availability. Its alternative proposal of estimating exposure with existing data has two serious disadvantages. First, although we would like to have information on many other factors besides mileage, we question the degree to which there is some adequate substitute for mileage data for constructing an exposure measure. Second, FHWA's current data on carriers concerning number of power units and type of operation are based on a one-time filing and updated only for carriers undergoing safety reviews or compliance audits. Depending on whether an analysis included or excluded carriers with dated information, estimates of exposure would have, respectively, uncertain validity and uncertain generalizability.

We agree with FHWA that mileage is an imperfect measure of exposure because it does not account for all factors affecting safety risk. However, some of these other factors can be adjusted for, at least in part, in an analysis. For example, one might make accident rate comparisons only between carriers with similar proportions of drivers who drive beyond a 100-mile radius, if one were concerned that the use of interstate highways was an unmeasured exposure risk. (This proposition follows to the extent that this factor is a proxy for the proportion of a carrier's operation that involves driving on interstate highways.)

In deciding a means of obtaining mileage data, we recommend that DOT reconsider its stance on directly collecting this data from carriers. The burden of answering a single question about mileage appears quite modest. Many carriers would already have mileage data available from ICC reporting, drivers' logbooks, vehicle maintenance records, or other sources. In any event, mileage data would seem to require only annual checks of trucks' odometers for changes in mileage, followed by a summing up of the mileage for all trucks operated by a carrier. Carriers with several fleets or sites would have to take the additional step of summing up mileage across these fleets or sites.

Driver Quality and Compliance as Predictors

DOT is convinced that the new commercial driver's license regulations, elimination of multiple driver's licenses, and the establishment of the Commercial Driver's License Information System will improve driver quality and compliance, and that certain data systems will give it "the capability to track developments with respect to age and experience of drivers and take further action as necessary." We agree that the agency could track drivers in this way and that the resulting information on individual drivers could be useful for many purposes. However, for the purposes of the enforcement model as discussed in this report, there are certain technical requirements for usable data, such as the capacity to link each driver with an employing carrier. FHWA could analyze the data requirements of the enforcement model to determine if the two data sets cited by the agency could be used.

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