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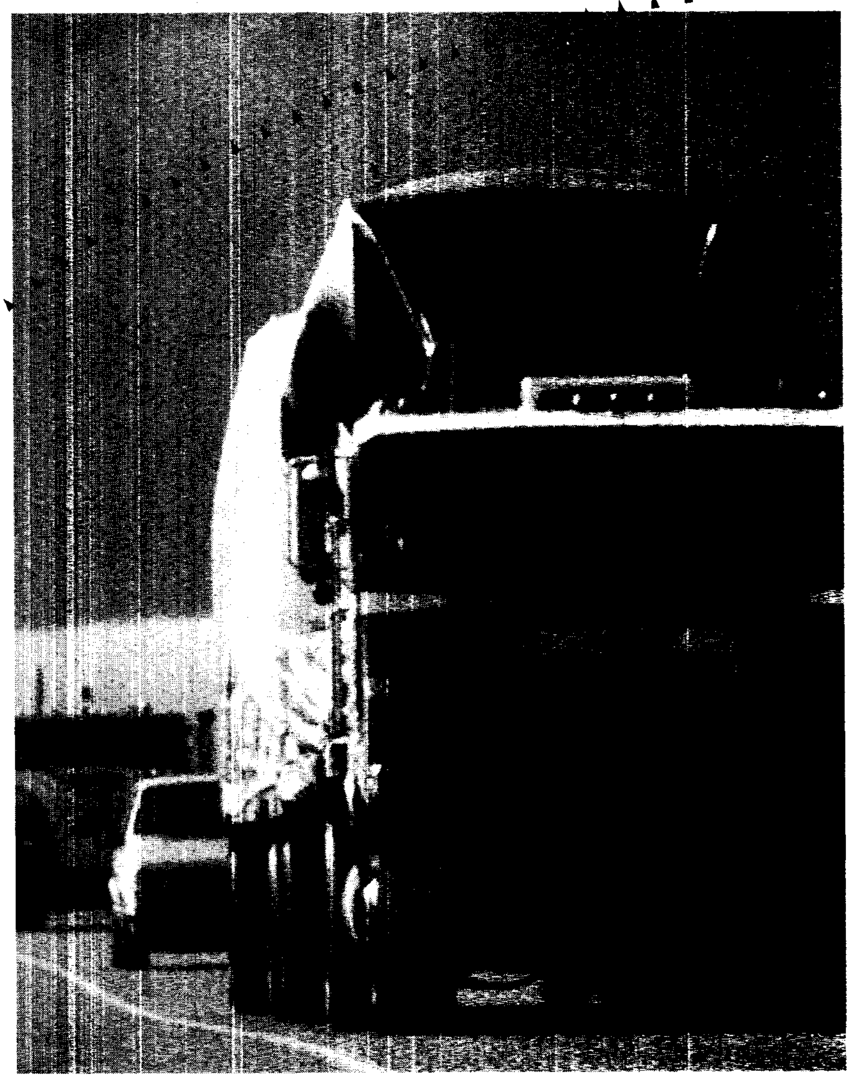

Motor Carrier Compliance Reviews: Measuring Their Impact on Improved Safety Performance Among Interstate Freight Motor Carriers Based in Minnesota

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16. Abstract (Limit: 200 words)

This study seeks to measure the safety performance of compliance reviews (CRs) conducted in Minnesota under the Motor Carrier Safety Assistance Program (MCSAP). This study employs data gathered by the Federal Highway Administration surrounding two MCSAP activities: compliance reviews and roadside inspections. It specifically investigates the change in a carrier's annual out-of-service violation rate (OOS) in response to receiving a review or a higher number of inspections.

A measurable reduction in a carrier's OOS rate occurs in the year after a CR, according to the data. The annual OOS rate appears to be a viable measure of the impact of a compliance review, given that a carrier's vehicles and drivers are adequately inspected in the year following a CR.

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Final Report

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EXECUTIVE SUMMARY

This study is concerned with measuring the safety performance of **compliance reviews (CRs)** conducted in Minnesota under the Motor Carrier Safety Assistance Program (MCSAP). The Motor Carrier Safety Assistance Program (MCSAP) was established under the Surface Transportation Act of 1982, and is administered by the Federal Highway Administration (FHWA). MCSAP provides grants to state and eligible territories to enforce the Federal Motor Carrier Safety and Hazardous Materials Regulations (FMCSR and HMR).

This study employs data gathered by the Federal Highway Administration (FHWA) surrounding two MCSAP activities: (1) *compliance reviews (CRs)* and (2) *roadside inspections*. This study's goal is to use this historical data to: (1) test the hypothesis that CRs have a positive impact on motor carrier safety practices in Minnesota, and (2) offer a performance measure of this impact among similar types of carriers. The datasets included CR records from 1992-1994, roadside inspections from 1992-1995 and characteristic data on Minnesota-based interstate freight carriers.

The adopted model attempts to measure safety outcomes and does not use a traditional approach using accident data, since accident data can be problematic for reasons related to the sparseness of accidents themselves and lack of data linking motor carriers to accident causation. Rather, information discovered from roadside inspections is used as an indicator of a carrier's safety practice. Specifically, the industry's response to a CR is measured using the occurrance of severe violations from roadside inspections, namely, the frequency of out-of-service (OOS) violations or, *OOS rate*. Here, the assumption is that OOS violations identify imminent dangers to highway safety and a higher accident risk for the associated carrier. However, unlike previous utilization of out-of-service rate, the focus is not on an individual carrier's response, but on the response of specific *segments* of motor carrier industry. The adopted model compares the average OOS rate of carriers that had a CR to the OOS rate of *similar* carriers that have not recently had a CR.

Similarity among carriers is determined by characteristics such as fleet size, average annual vehicle mileage and average haul distance in addition to a carrier's classification as "authorized for-hire," "exempt for-hire," "private" and hazardous material carriers.

Results

The frequency of inspections for different types of carriers was examined. From roadside inspection data, it was found that carriers with larger fleets, substantial long-haul operations or hazardous material registration were most likely to be inspected at the roadside. Characteristics that influenced a lower inspection frequency were smaller fleets, low average annual vehicle milage or classification as a private or exempt for-hire carrier. It was also found that roughly 50% of the carriers with known CRs were without a record of an inspection; these tended to be carriers with small fleets and/or low average annual vehicle milage. The data suggests that the estimated OOS rate becomes more accurate as a carrier experiences more inspections.

A measurable reduction in a carrier's OOS rate occurs in the year after a CR. This result was most apparent when separating all carriers into three primary groups: (1) authorized for-hire, (2) exempt for-hire and (3) private carriers, and then further separating each of these groups into three smaller groups based on the carrier's fleet size (1 vehicle, 2-5 vehicles, or more than 5 vehicles). In eight of these nine subpopulations, the model showed statistically significant results. The model revealed a positive response from six of these subpopulations: carriers subject to a CR exhibit lower average annual OOS rates (12 - 37%). However, the model estimated an increase in the annual OOS rate for owner/operators (73%) and private carriers with 2-5 vehicles (65%). Exempt for-hire carriers with a single vehicle, did not exhibit a significant response to a CR.

Conclusion

Annual OOS rate appears to be a viable measure of the impact of a compliance review, given that a carrier's vehicles and drivers are adequately inspected in the year following a CR. It is important to verify and share these results with all affected regulatory agencies, transportation research institutions, the motor carrier industry and the public.

A partnership for timely data exchange is recommended between the agencies that conduct CRs and roadside inspections. Specifically, if performance measurement of this kind is desired, there is a need to ensure that most carriers receiving CRs are adequately inspected at the roadside in the ensuing year.

1. INTRODUCTION

This study is concerned with measuring the safety performance of **compliance reviews (CRs)** conducted in Minnesota under the Motor Carrier Safety Assistance Program (MCSAP). MCSAP was established under the Surface Transportation Act of 1982, and is administered by the Federal Highway Administration (FHWA). MCSAP provides grants to state and eligible territories to enforce the Federal Motor Carrier Safety and Hazardous Materials Regulations (FMCSR and HMR), or comparable state regulations regarding commercial motor vehicle safety.

Earlier research indicates that CRs are a cost-effective means of reducing accident rates [1]. However, using accidents as a performance-based measurement of CRs is problematic, since accident data can be sparse, often lacks enough information regarding accident causation, and is reactive rather than proactive in assessing safety outcomes.

This study takes a different approach, one utilizing the common legal backbone behind CRs and roadside inspections: the FMCSR. The assumption is made that roadside inspections exist to enforce, on a daily basis, the FMCSR with regard to the vehicles and drivers of the interstate motor carrier industry. Hence, the general hypothesis is that roadside inspections offer timely, reproducible, independently-gathered and tractable data concerning a carrier's actual safety practice on the roadway. Further, an attempt is made to gauge the industry's response to a CR using the occurrance of severe violations from roadside inspections, namely, the frequency of "out-of-service" violations or, *out-of-service rate*. However, unlike previous examinations of out-of-service rate, the focus is not on an individual carrier's response, but on the response of specific *segments* of motor carrier industry. This study analyzes a substantial sample of the historical data and investigates a method to measure the educational element of CRs toward improving safety in Minnesota's motor carrier industry.

1.1 Background

CRs are audits conducted on motor carriers to determine their compliance with federal safety regulations, including; 1) insurance, 2) driver qualifications, 3) vehicle maintenance and inspection reports, 4) freight bills and accounts, 5) driver hours of service records (logbooks), and 6) vehicle accident records. Until recently, a CR resulted in a carrier receiving a safety rating (Satisfactory, Conditional or Unsatisfactory). However, in March of 1997, a federal court ruling caused the FHWA to place the carrier rating scheme on hold.

CRs were preceded in the MCSAP by a non-enforcement audit called a Safety Review (SR), which was intended to be completely educational. While the SR's replacement , the CR, is still intended to be educational, carriers may also face stiff fines for willful noncompliance with the regulations. Nonetheless, it is the "educational" element of a CR that is of most interest in this study. Therefore, to be able to use as much of the available historical data as possible, we use CRs and SRs synonymously.

The majority of funds received by the states through MCSAP are used for roadside inspections of commerical vehicles. For example, in FY 1994, the MCSAP resulted in 1,961,800 vehicle inspections and 10,785 compliance reviews nationwide. By comparison, Minnesota conducted 511 CRs on carriers domiciled in the state. However, interstate carriers from Minnesota may be subjected to roadside inspections in any state in which they travel. All roadside inspection and CR data for carriers is maintained by FHWA in the SafetyNet database. The premise of this study is to examine carriers who have experienced a CR, and determine whether their compliance during roadside inspections has statistically improved.

In Minnesota, two agencies share the MCSAP grant. The Minnesota Department of Public Safety (MDPS), Commerical Vehicle Section is the lead agency and uses MCSAP funds to conduct roadside inspections, traffic enforcement, accident reconstruction, inspector training and public awareness campaigns such as "Share the Road." The Minnesota Department of Transportation, Office of Motor Carrier Services (OMCS), conducts CRs, inspection repair audits, hazardous materials shipper reviews, hazardous materials dock audits, adminstrates SafetyNet databases, and provides training on commercial vehicle and hazardous materials regulations.

While each state or territory is responsible for the activities performed under the MCASP, these safety activities generally fall into several main categories: 1) roadside enforcement, i.e., commercial vehicle inspections 2) traffic enforcement, 3) CRs and other audits, and 4) education/outreach. It is fair to say, that in most, if not all states, the majority of MCSAP resources are directed toward roadside inspection activities. Nationally, FHWA has declared that for MCSAP to become a performance-based program it must focus on accident reduction, and "with this approach, inspections become part of a performance based plan for the state" [2]. However, the utilization of accidents as the sole measure of successful performance, particularly regarding the CR element of the MCSAP, is confronted with several problems:

1. Accident data has historically been inconsistently reported, collected and interpreted [3].
2. In 1995, reports to the National Highway Traffic Safety Administration indicate that 72% of fatal accidents involving trucks were the fault of the other driver [4].
3. Many other factors such as weather, geometric design and traffic laws have significant influence on accidents.

While accident or crash reduction may be a fair measure of roadside enforcement programs, it is difficult, at best, to directly link crashes to other elements of the MCSAP program, such as CRs and education/outreach. To reiterate, the purpose of this study is to develop a performance based measure for the CR element of the MCSAP.

2.0 PROJECT GOALS

The outcome of a roadside inspection known as an "out of service violation" is used in this study as an indication of an unsafe commercial vehicle operated by a specific motor carrier. Out of service (OOS) violations are severe violations of the Federal Motor Carrier Safety Regulations (FMCSR) relating to the vehicle or the driver. If a roadside inspection results in one or more OOS violations, the vehicle and/or the driver is immediately prohibited from further travel or, using the terminology of the regulations, placed "out of service." The carrier may also receive citations for the OOS infractions and, until compliance with the regulations is reached, the vehicle and/or driver would not be allowed to continue.

Whether associated with a vehicle or a driver, OOS violations identify imminent dangers to highway safety and imply a higher risk of a traffic accident involving that particular vehicle or driver. Further, since the FHWA SafetyNet database identifies the *carrier* for which the vehicle and driver are operating, it possible to estimate a specific carrier's annual OOS rate (average number of OOS violations per roadside inspection for a particular calendar year). Consequently, the goal of this study is to determine the usefulness of a carrier's OOS rate as the focus of comparative measurement in understanding the safety benefit of performing CRs.

2.1 Issue of Similarity

To generate meaningful results, only similar carriers should be compared when examining the safety impact of a CR. For this study, *similarity* is defined using a number of physical characteristics (carrier type, fleet size, annual mileage, etc.). In other words, the aggregate sample of carriers is separated into several smaller groups, where each of these smaller subpopulations of carriers share a set of physical characteristics. Consequently, for each of these smaller groups of similar carriers, a comparative analysis can be applied between carriers that have participated in a CR and those that have had little or no exposure to this regulatory process. The result of restricting the analysis to similar carriers is a more refined understanding of the possible impact that may be learned from the available data.

2.2 Datasets Used

The FHWA supplied three raw data samples from the SafetyNet database. The datasets derived for this study are explained below.

1. Roadside inspections for vehicles associated with MN interstate freight carriers, during the period 1/1/92 to 12/31/95 (~75,000 inspections).

2. MN interstate freight carriers receiving a CR during the period 1/1/92 to 12/31/94 that also experienced at least one roadside inspection during the period 1/1/93 to 12/31/95 (~1200 reviews).

3. Uniform physical data on MN interstate freight carriers from the Census database (5968 carriers).

2.3 Definition of Out-of-Service (OOS) Rate

For this study the OOS rate of a carrier is defined as the fraction of inspections conducted in a calendar year that result in one or more OOS violations.

$$OOS\ rate = \frac{No.\ of\ inspections\ with\ OOS\ violations}{No.\ of\ inspections}$$

3.0 METHODS

3.1 Hypothesis

If there is a safety benefit to conducting motor carrier CRs, and if one way this benefit is naturally (if not directly) expressed is in a change in a carrier's OOS rate, we expect that OOS rates would be comparatively lower for at least a short time after a conducting a CR. Here, the comparison is against similar carriers that have never or, not recently, received a CR. Formally, we hypothisize that

H: Carriers receiving a CR respond with lower OOS rates in the year following the CR

3.2 Finding Groups of Similar Carriers

Two different procedures are used to separate carriers into initial categorical groups.

Categorical Separation Procedure 1

The first procedure separates the aggregate sample into carriers of four types, refering to whether or not a carrier has been registered for transportation of hazardous materials (Hazmat) and whether or not they are incorporated. This is diagramed in Figure 3.1

1) **Hazmat, incorporated** carriers
2) **nonHazmat, incorporated** carriers
3) **Hazmat, unincorporated** carriers
4) **nonHazmat, incorporated** carriers

Categorical Separation Procedure 2

The second procedure separates the the aggregate sample of carriers into three carrier types. This is diagramed in Figure 3.2.

1) authorized **For-hire** carriers
2) **Private** carriers
3) **Exempt** for-hire carriers

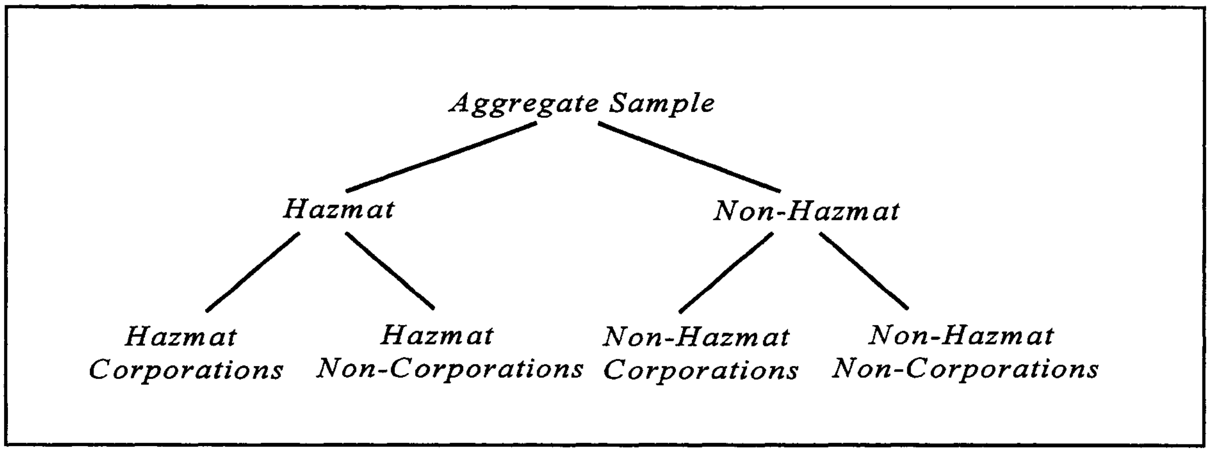

Figure 3.1 Categorical Separation Procedure 1

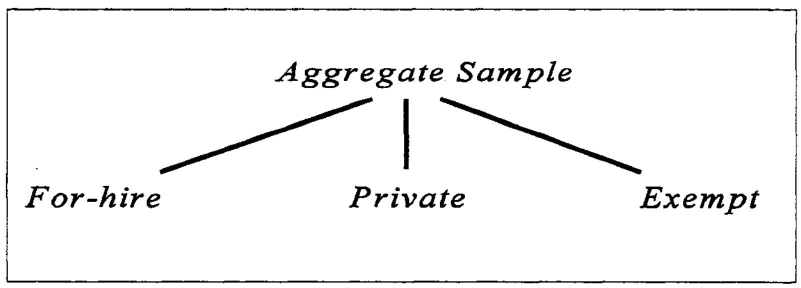

Figure 3.2 Categorical Separation Procedure 2

The population of carriers within each of the categorical groups created by either separation method will still vary according to extent of service. Therefore, for tighter focus on carrier populations, we further break down categorical groups by focusing on *one* of three parameters that are developed and calculated for each carrier in the aggregate sample of carriers:

(1) size of fleet	{Size parameter}
(2) average annual vehicle miles	{AVM parameter}
(3) average haul distance	{Haul_distance parameter}

For example, using categorical separation procedure 2, For-hire carriers are further described by characterizing them as short-haul, medium-haul or long-haul carriers based on the calculated Haul_distance parameter. The same is done for the Private and Exempt categories of carriers.

Appendix A presents the algorithms used to calculate these parameters and results of the three grouping strategies in both procedures.

3.3 Data Analysis

There are two main tasks for this study:

(1) analyze the data integrity from CRs and roadside inspections
(2) construct a model to test the hypothesis.

3.3.1 Preliminary Data Analysis

<u>Roadside Inspections</u>: Descriptive statistics were used to gain insight about roadside inspections and answer these questions:

a) Is the frequency of inspection influenced by a carrier's type and size?
b) What are the most common types of out of service violations?
c) Is the "probability of an inspection" dependent on an inspection site, on the carrier itself, or both?

Appendixes B, C and D contain the approaches and tabulations of the results of these analyses.

<u>CRs</u>: Six component factors contribute to a carrier's safety rating resulting from a CR. Each component factor identifies a specific area of safety practice (driver qualifications, vehicle maintenance, operational practice, etc.), and each is rated separately with respect to compliance with the FMCSR [5]. The objective of this analysis is to identify component factors most frequently rated 'unsatisfactory' or 'conditional.' The component factors identified in this way are the most likely to contribute to an overall 'unsatisfactory' or 'conditional' safety rating. The results of this analysis is contained in Appendix E.

3.3.2 Model Construction and Hypothesis Testing

Within each subpopulation of similar carriers, we examine the OOS rates of two groups. The *treatment group* consists of carriers exposed to a CR, while the *control group* consists of carriers that did not receive a CR in the years 1991, 1992, 1993 and 1994. The OOS rates for each group of a subpopulation were estimated for the year following a CR.

***Control group*:**	carriers who did not experience a CR
***Treatment group*:**	carriers who received a CR during 1992, 1993, 1994

To test the hypothesis, the mean OOS rates for treatment group and control group are estimated separately, and then a standard nonparametric statistical test is applied to measure the significance of the difference in these mean OOS rates. Only if there is a statistically significant difference in these two estimated OOS rates is it fair to conclude that conducting a CR has a measurable effect on a subpopulation of carriers. Further, if the mean OOS rate of the treatment group is lower than the mean OOS rate of the control group, then we can conclude that conducting a CR on a typical carrier of the subpopulation has a positive effect on (lowering) its OOS rate. Conversely, if the mean OOS rate of the control group is lower than the mean OOS rate of the treatment group, then we can conclude that conducting a CR on a typical carrier of the subpopulation has a negative effect on its OOS rate.

The model employed is a version of the *Two-sample Location Problem* [6, 7], a classic statistics problem that compares two sample means. The Two-sample Location Problem, as we have applied it to a group of similar carriers, consists of estimating the difference in the mean values of the OOS rates of the control and treatment groups. Such a test statistic is obtained from Wilcoxon's 'distribution-free rank sum test' [8].

To garner an understanding of the significance of the test results, a 'confidence level' is attached to this estimated difference (the target confidence level is 90% for each test). Additionally, we calculate an associated confidence interval within which the estimated difference is allowed to vary. Finally, in order to justify a significant difference in the estimated mean OOS rates of the control and treatment groups, the confidence interval cannot include the number zero. The estimator used to measure the difference in the sample means is the so-called Walsh average [9] and the confidence interval employed is due to Moses [10].

4.0 RESULTS

4.1 Preliminary Data Analysis

4.1.1 Statistics for Roadside Inspections

- For a given type of carrier (Hazmat/Incorporated, Non-Hazmat/Unincorporated, For-hire, Private, Exempt), *vehicle*-populations are inspected fairly uniformly with respect to average annual vehicle mileage. This means low-mileage carriers are inspected commensurately with high-mileage carriers of the same type, highlighting a carrier's 'annual vehicle mileage' as an exposure variable in the roadside inspection process.

- Carrier fleet size contributes to the carrier's exposure to roadside inspections; i.e., larger fleets tend to be inspected more frequently at the roadside.

- When normalized by average vehicle mileage, single-vehicle For-hire carriers (assumed to be owner/operators) are inspected at virtually the same rate (20 inspections per million miles annually) as single-vehicle Private carriers (22 inspections per million miles annually). Single-vehicle Exempt carriers are inspected about half as often (13 inspections per million miles annually).

- Normalized by average vehicle mileage, For-hire carriers with fleets of 2 - 5 vehicles are inspected 1.4 times as often (52 inspections per million miles annually) as similar Private carriers (37 inspections per million miles annually).

- Normalized by average vehicle mileage, For-hire carriers with fleets of more than 5 vehicles are inspected 3 times as often (375 inspections per million miles annually) as similar Private carriers (120 inspections per million miles annually) and 6 times as often as all carriers classified as both Private <u>and</u> For-hire (67 inspections per million miles annually).

- Normalized by average vehicle mileage, inspection frequencies for incorporated carriers are 2 - 3 times those organized as individual or partnership businesses.

- When normalized by average vehicle mileage, inspection frequencies for registered Hazmat carriers are 2 to 4 times that of non-Hazmat carriers. In part, this maybe explained by the fact that many large general commodity less-than-truckload carriers in Minnesota are also registered Hazmat carriers. Supporting this is the previous finding that inspection frequencies for large For-hire carriers are 3 times greater than similar large Private carriers. However, since Hazmat registered carriers comprise approximately 10% of the population of interstate freight carriers in Minnesota, and these carriers received approximately 40% of all inspections performed during the period from 1992 to 1995, there may be a bias at inspection sites toward selecting vehicles that display Hazmat placards. Since the datasets received from FHWA did not contain placarding information, the analysis was unable to correlate this higher inspection frequency with Hazmat vehicle placarding requirements.

- Vehicle-related OOS violations occur approximately 3 - 4 times more frequently than driver-related OOS violations.

- Nearly 90% of all driver-related OOS violations are related to problems with the driver's required 'record of duty' (hours-of-service and missing documents)

- The most common vehicle OOS violations in the dataset are brake-related (53%). The second and third most common are related to 'steering/suspension/wheels/rims' (18%) and 'lighting devices' (15%).

- Among Hazmat-registered carriers, Hazmat-related OOS violations occur infrequently (3%), while the frequency of vehicle and driver related OOS violations are similar to that of non-Hazmat carriers. For carriers without Hazmat registration, Hazmat-related OOS violations are rare.

- The most common Hazmat OOS violations are related to 'placarding and proper markings on Hazmat containers and tanks' (43%), while the second most common involve 'cargo tank/loading & securement, and radioactivity' (40%).

- In general, the OOS rate at fixed inspection sites appears as carrier-dependent and site-independent. The result, obtained by analyzing well-inspected carriers, suggests that the most accurate estimate of a carrier's OOS rate is obtained when its vehicles/drivers are inspected with regularity.

- A comparison of the OOS rates at the Minnesota-administered 'St Croix' scale and the Wisconsin-administered 'Hudson' scale demonstrates that the OOS rates of the same carriers at both sites are similar, indicating that OOS inspection criteria and inspection procedures are similar as well.

4.1.2 Statistics for CRs

- Driver factors, operational factors and vehicle factors are the most common individual factors negatively affecting overall ratings in CRs.

- 52% of all CRs in the dataset showed the driver factor rated as conditional.

- The general regulations factor was rarely rated unsatisfactory, and when rated conditional, this factor always ranked behind the driver, operational and vehicle factors.

- The Hazmat factor did not affect the review of any carrier that did carry Hazmat registration, but this factor rarely appeared as conditional or unsatisfactory even among Hazmat-registered carriers.

- The accident rate factor is commonly rated conditional among Hazmat-registered carriers that received conditional or unsatisfactory overall ratings.

- The accident rate factor rarely affected the overall rating of carriers without Hazmat registration.

4.2 Modeling the Effectiveness of CRs

Results from the CR model and significance tests are shown in tables for each carrier group.

- Overall, carriers that received a CR have an average OOS rate 9% lower than the average for carriers without CRs.

- Among ***For-hire carriers*** (Table 4.1), carriers having a CR had significantly lower OOS rates when compared to carriers without a CR. Fleets of 2 - 5 vehicles showed a 24% decrease in mean OOS rate, while fleets greater than 5 vehicles showed a 12% decrease in mean OOS rate. The exception among the For-hire classification is for single-vehicle carriers where OOS rates actually rose significantly (73%) after receiving a CR.

Table 4.1 For-hire Carriers (Size)

Size of Fleet	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level (%)	%Δ
1 vehicle	0.186(67)	0.322(33)	Pass	90	**+73**
2-5 vehicles	0.371(77)	0.281(54)	Pass	90	**-24**
6 or more	0.321(294)	0.281(89)	Pass	90	**-12**

- ***For-hire carriers*** separated by the derived Haul_distance parameter (Table 4.2) showed significant decreases in mean OOS rates after receiving a CR: short-haul (38% lower), medium-haul (25% lower), and long-haul (10% lower).

Table 4.2 For-hire Carriers (Haul_distance)					
Haul Distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level (%)	%Δ
Short haul	0.343(18)	0.216(11)	Pass	90	**-38**
Med. haul	0.371(59)	0.298(35)	Pass	80	**-25**
Long haul	0.321(361)	0.288(130)	Pass	90	**-10**

- ***Private carriers*** (Table 4.3) showed mixed results when separated by fleet size. Lower OOS rates were found among carriers with single-vehicle fleets (30%) and fleets of greater than 5 vehicles (31%) after receiving a CR; while carriers with fleets of 2 - 5 vehicles exhibited a significant increase in OOS rate (65%) after receiving a CR.

Table 4.3 Private Carriers (Size)					
Size of Fleet	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
1 vehicle	0.356(94)	0.248(50)	Pass	90%	**-30**
2-5 vehicles	0.209(133)	0.345(97)	Pass	90%	**+65**
6 or more	0.349(121)	0.241(81)	Pass	90%	**-31**

- ***Private carriers*** separated by the derived Haul_distance parameter (Table 4.4) also differed according to subgroup: the mean OOS rate rose significantly for short-haul carriers (9%), dropped significantly for medium-haul carriers (29%), and there was no significant change for long-haul carriers.

Table 4.4 Private Carriers (Haul_distance)					
Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	0.278(119)	0.303(65)	Pass	90%	**+9**
Med. haul	0.405(178)	0.287(131)	Pass	90%	**-29**
Long haul	0.226(51)	0.260(32)	Fail	90%	-----

- *Exempt carriers* (Table 4.5) showed a significant decrease in mean OOS rates among fleets of more than one vehicle (37%) after a CR. There was no significant difference in the mean OOS rate for single-vehicle carriers after a CR. When separated by the Haul_distance parameter (Table 4.6), only long-haul Exempt carriers exhibited a significant decrease (22%) in mean OOS rate after a CR.

Table 4.5 Exempt Carriers (Size)					
Size of Fleet	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
1 vehicle	0.105(48)	0.177(38)	Fail	80%	-----
2 or more	0.295(80)	0.185(60)	Pass	90%	**-37**

Table 4.6 Exempt Carriers (Haul_distance)					
Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	----------------	------------ not	enough data for	testing -----	-----
Med. haul	0.175(59)	0.167(37)	Fail	80%	-----
Long haul	0.248(58)	0.194(51)	Pass	90%	**-22**

- ***Carriers classified as both For-hire and Private*** (Table 4.7) showed a significant drop in the mean OOS rate after a CR (24%).

Table 4.7 For-hire/Private Carriers					
Size of Fleet	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
all fleets	0.406(26)	0.310(13)	Pass	90%	**-24**

- In four of the six groups that described carriers as ***Non-Hazmat carriers*** (Tables 4.8 and 4.9), those that had a CR exhibit OOS rates that are significantly lower than the OOS rates of similar carriers without a CR.

- Depending on the non-Hazmat group identified, the reduction in OOS rate is between 12% and 39%.

Table 4.8 Non-Hazmat/unincorporated Carriers (Haul_distance)					
Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	0.382(113)	0.232(62)	Pass	90%	**-39**
Med. haul	0.296(70)	0.356(46)	Fail	90%	-----
Long haul	0.329(131)	0.227(76)	Pass	90%	**-31**

Table 4.9 Non-Hazmat/incorporated Carriers (Haul_distance)					
Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	0.303(223)	0.244(116)	Pass	90%	**-19**
Med. haul	0.312(94)	0.377(46)	Fail	90%	-----
Long haul	0.320(189)	0.281(97)	Pass	90%	**-12**

- ***Carriers registered as hazardous material haulers*** (Table 4.10 and Table 4.11), it was found that in some cases not enough data was present for a significance test. For all of the Hazmat/unincorporated carrier groups, there was insufficient data to apply the model. However, for the three Hazmat/incorporated carrier groups, we found no significant difference in the mean OOS rate of carriers that had a CR as compared with similar carriers without a CR. From preliminary analyses, it was found that incorporated Hazmat-registered carriers (believed to be large, general commodity carriers) are very well inspected at the roadside. It is possible that this higher exposure to roadside inspections creates a dominant effect on these carriers' OOS rates, and makes it difficult to measure significant changes in OOS rates after CRs are applied.

Table 4.10 Hazmat/incorporated Carriers (Haul_distance)

Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	0.266(46)	0.249(32)	Fail	90%	-----
Med. haul	0.364(20)	0.396(12)	Fail	90%	-----
Long haul	0.290(49)	0.339(17)	Fail	90%	-----

Table 4.11 Hazmat/unincorporated Carriers(Haul_distance)

Haul distance	OOS rate w/o CRs (#samples)	OOS rate w/ CRs(#samples)	Significance test (Pass/Fail)	Confidence Level	%Δ
Short haul	----------------	----------- not	enough data for	testing -----	-----
Med. haul	----------------	----------- not	enough data for	testing -----	-----
Long haul	----------------	----------- not	enough data for	testing -----	-----

5.0 CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of a CR toward improved safety practice

The event of a CR appears to have a measurable effect on lowering a carrier's OOS rate in the year following the review as compared with the OOS rates of carriers never reviewed or without recent exposure to the CRs. This makes sense when considering that, from the preliminary data analysis, the most problematic review factors are driver, operational and vehicle factors. Specifically, the infractions discovered within these areas during a review relate directly to those that would be discovered in a roadside inspection.

Using an interstate freight carrier's For-hire, Private, or Exempt classification, together with its known fleet size, appears to be the most reasonable way to establish subpopulations of carriers for measuring change in OOS rate. In particular, it was found that only three out of the nine carrier groups did not exhibit significantly lower mean OOS rates than those of similar groups without CRs. For one of these three groups, single-vehicle Exempt carriers, the mean OOS rate was not significantly different. The other two groups, For-hire owner/operators and Private carriers with fleets of 2-5 vehicle fleets, exhibited significantly higher OOS rates.

In the remaining six sub-populations, carriers receiving CRs exhibited significantly lower OOS rates in the year following these reviews as compared to OOS rates, in the same year, of similar carriers without CRs. The model revealed a significant positive response among large (fleets of greater than 5 vehicles) For-hire and Private carriers, where the reduction in OOS rates were 12% and 31% respectively, and for all Exempt carriers with more than one vehicle (OOS rates down 37%). Also of significance were lower OOS rates among For-hire carriers with fleets of 2-5 vehicles (24%), single-vehicle Private carriers (30%), and all carriers described as both For-hire and Private (24%).

Data requirements

As with any statistical approach to data analysis, results will be impacted by the quality of the data. In this model for the effectiveness of CR activities, we have encountered two areas of concern in the quality of the SafteyNet datasets. One centers on the completeness of information available in FHWA's Census database regarding physical characteristics (size of vehicle fleets, annual mileage, number of drivers) for Minnesota-based carriers. Many of the records in the extracted set of Minnesota-based carriers did not contain this required information (25%) and the associated carriers could not be included in our modeling analysis even though many of them had received a CR and/or were inspected at the roadside. An effort to increase the number of complete records extracted from the Census database would increase the size of the sample available for analysis.

The second area concerning data is with regard to obtaining an adequate estimate of a carrier's OOS rate, particularly for carriers recently receiving CRs. If a carrier's vehicles are not inspected in a given year, then the OOS rate for that year cannot be established. Also, from a practical point of view, the estimate of a carrier's annual OOS rate becomes more accurate as the number of its roadside inspections increases. Further, within this proposed model for evaluating the educational value of Minnesota's CR activities, there is a need to ensure that carriers receiving CRs are adequately inspected at the roadside in the ensuing year. Should this model be implemented, it is recommended that information identifying those carriers that recently received CRs be shared with inspectors at inspection sites in order to improve and maintain the accuracy of carriers' estimated OOS rates. A recommended rule-of-thumb is that two inspections per year should be a minimum for all but the largest carriers, where somewhere between five to ten inspections per year should be a minimum. When modeling a CR performance measure from OOS violation data, developing and maintaining timely information-sharing methods and technologies at roadside inspection sites will be of key importance.

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Appendix A

Algorithms for Grouping Similar Carriers

The population of carriers within each of the categorical groups created by either categorical separation procedure will still vary according to extent of service. Therefore, for tighter focus on carrier populations, we further break down categorical groups by focusing on ***one*** of three parameters that are developed and calculated for each carrier in the aggregate sample of carriers: (1) Size parameter, (2) Average Vehicle Mileage (AVM) parameter, and (3) Haul_distance parameter. The definitions/derivations of these parameters are given below along with their defined categorical values (C_Value).

*1. **Size parameter:***

Algorithm:	Size = (total # of drivers) + (total # of power units)	{Procedure 1}
	Size = (total # of power units)	{Procedure 2}
	C_Value (Size) = [small, medium, or large]	

*2. **Average Vehicle Mileage (AVM) parameter:***

Algorithm:	AVM = (total annual mileage) / (total # of power units)	{both procedures}
	C_Value (AVM) = [low, medium, or high miles]	

To obtain the C_value of a parameter for any particular carrier, each of the categorical groups (Figure 1) are separated into three approximately equal-sized subsets using the values of the Size or AVM parameters. Thus, we have two different views of the aggregate sample of carriers.

View 1	12 groups (9 in procedure 2) that separate the master recordset (Census database) according to ORG/HAZMAT type and the C_Values of the Size parameter.
View 2	12 groups (9 in procedure 2) that separate the master recordset (Census database) according to ORG/HAZMAT type and the C_Values of the AVM parameter.

*3. **Haul_distance parameter:***

A third parameter was developed in an attempt to assess an 'average haul distance per vehicle.' The goal is to find groups that represent 'short haul', 'medium haul' and 'long haul' types of carriers, however, the needed 'number of road trips made per year' is a statistic that is unavailable in the database. Thus, an alternative approach is adopted and should correlate well with 'average haul distance per vehicle'. Motivation for the development of the Haul_distance parameter stems from the understanding that 'average haul distance' has been viewed as an explanatory variable in other research [11, 12]. The grouping that results from use of this parameter was used only in the modeling approach for evaluation of CR activities and not in any of the preliminary data analyses. The Haul_distance parameter is explained next.

Algorithm: For every carrier having complete characteristic data, two variables are formed from data:

Variable (1): Average # of miles per driver = (total annual mileage) / (total # of drivers)
Variable (2): Ratio of vehicles to drivers = (total # of power units) / (total # of drivers)

Variable (1) is used to form a preliminary grouping of the typed carrier groups. This results in 12 preliminary groups (9 in Procedure 2) where each of the categorical groups are separated into three approximately equal-sized subgroups representing 'Low miles', 'Medium miles', and 'High miles' carriers. This procedure is similar to AVM parameter except with respect to the carrier's total drivers instead of total power units.

Variable (2), the vehicle-to-driver ratio, is then used to remap the carriers in these preliminary groups to groups which will represent 'Short haul', 'Medium haul' and 'Long haul' types. Here the idea is that carriers with low vehicle-to-driver ratios tend to employ drivers on several shifts using the same vehicles and are more likely to be 'local' haulers by nature. Conversely, carriers with high vehicle-to-driver ratios (approx 2.0 or higher) a more likely to dispatch trucks on longer routes. With these ideas in mind, carriers with vehicle-to-driver ratios smaller than 0.9 are shifted from their current group to the neighboring group of lower mileage (if the carrier's current subgroup is 'Short miles', its new group does not change). Carriers with vehicle-to-driver ratios larger than 2.0 are shifted from their current group to the neighboring group of higher mileage (if the carrier's current group is 'Long miles', its new group does not change). When variable (2) has been used to remap all of the carriers, then what were low, med., and high miles groups, now become the new groups 'Short haul', 'Medium haul' and 'Long haul':

C_value (Haul_distance) = [Short, Medium, or Long haul]

Using the Haul_distance in conjunction with the carrier type (i.e. ORG/Hazmat), yields the third view of the aggregate sample of Minnesota-based carriers.

View 3 12 groups (9 in method 2) that separate the master recordset (Census database) according to ORG/Hazmat type and the C_Values of the Haul_distance parameter.

The resulting three views for each categorical separation procedure of the master recordset are given on the following pages.

Categorical Separation Procedure 1: Hazmat/Corp variables

1. Focus on Size parameter:

<u>Non-Hazmat/Non-corporations</u>

Group ID	C_Value	# of carriers	range of 'Size'
1001	small	1084	< 3
1002	medium	294	3 - 4
1003	large	1006	> 4

<u>Non-Hazmat/Corporations</u>

Group ID	C_Value	# of carriers	range of 'Size'
2001	small	1147	< 5
2002	medium	738	5 - 10
2003	large	997	> 10

<u>Hazmat/Non-corporations</u>

Group ID	C_Value	# of carriers	range of 'Size'
1101	small	37	< 4
1102	medium	25	4 - 8
1103	large	33	> 8

<u>Hazmat/Corporations</u>

Group ID	C_Value	# of carriers	range of 'Size'
2101	small	221	< 9
2102	medium	180	9 - 26
2103	large	207	> 26

2. Focus on AVM parameter:

<u>Non-Hazmat/Non-corporations</u>

Group ID	C_Value	# of carriers	range of 'AVM'
1001	Low-miles	800	< 18 000
1002	Medium-miles	781	18 000 - 55 000
1003	High-miles	803	> 55 000

Non-Hazmat/Corporations

Group ID	C_Value	# of carriers	range of 'AVM'
2001	Low-miles	961	< 12 400
2002	Medium-miles	939	12 400 - 35 000
2003	High-miles	982	> 35 000

Hazmat/Non-corporations

Group ID	C_Value	# of carriers	range of 'AVM'
1101	Low-miles	32	< 19 000
1102	Medium-miles	30	19 000 - 38 750
1103	High-miles	33	> 38 750

Hazmat/Corporations

Group ID	C_Value	# of carriers	range of 'AVM'
2101	Low-miles	203	< 16 850
2102	Medium-miles	201	16 850 - 46 667
2103	High-miles	204	> 46 667

3. Focus on Haul_distance parameter:

Non-Hazmat/Non-corporations

Group ID	C_Value	# of carriers
1001	short-haul	917
1002	medium-haul	618
1003	long-haul	849

Non-Hazmat/Corporations

Group ID	C_Value	# of carriers
2001	short-haul	1124
2002	medium-haul	620
2003	long-haul	921

Hazmat/Non-corporations

Group ID	C_Value	# of carriers
1101	short-haul	36
1102	medium-haul	26
1103	long-haul	33

Hazmat/Corporations

Group ID	C_Value	# of carriers
2101	short-haul	209
2102	medium-haul	173
2103	long-haul	226

Categorical Separation Procedure 2: For-hire/Private/Exempt classification

***4. Focus on Size parameter*:**

For-hire

Group ID	C_Value	# of carriers	range of 'Size'
1001	small	365	1
1002	medium	377	2 - 5
1003	large	464	> 5

Private

Group ID	C_Value	# of carriers	range of 'Size'
2001	small	1171	1
2002	medium	1233	2 - 5
2003	large	749	> 5

Exempt

Group ID	C_Value	# of carriers	range of 'Size'
1101	small	514	1
1102	medium	401	> 1

For-hire and Private

Group ID	C_Value	# of carriers	range of 'Size'
2100	All carriers	81	----------

5. Focus on AVM parameter:

For-hire

Group ID	C_Value	# of carriers	range of 'AVM'
1001	Low-miles	286	< 35 000
1002	Medium-miles	440	35 000 - 80 000
1003	High-miles	480	> 80 000

Private

Group ID	C_Value	# of carriers	range of 'AVM'
2001	Low-miles	2567	< 35 000
2002	Medium-miles	486	35 000 - 80 000
2003	High-miles	100	> 80 000

Exempt

Group ID	C_Value	# of carriers	range of 'AVM'
1101	Low-miles	293	< 35 000
1102	Medium-miles	365	35 000 - 80 000
1103	High-miles	915	> 80 000

6. Focus on Haul_distance parameter:

For-hire

Group ID	C_Value	# of carriers
1001	short-haul	122
1002	medium-haul	338
1003	long-haul	746

Private

Group ID	C_Value	# of carriers
2001	short-haul	1448
2002	medium-haul	1418
2003	long-haul	287

Exempt

Group ID	C_Value	# of carriers
1101	short-haul	189
1102	medium-haul	380
1103	long-haul	346

Appendix B

Inspection Frequency by Group (Size and AVM)

We examine the inspection frequency of carriers in the dataset that were subject to inspections throughout the years 1992 - 1995. There were 74740 total inspections performed on 3668 carriers. Both methods of categorically separating these carriers into smaller carrier groups were used (i.e., Hazmat/Corp variables vs. For-hire/Private/Exempt variables).

Approach

A small carrier identified using the 'Size' parameter is not necessarily low-AVM. In correlating the 'Size' parameter to the 'AVM' parameter, a fairly low correlation coefficient of 0.343 is found, which supports analyzing both of these characteristics. Average yearly inspection frequencies were estimated using the 12 'Size' groups and the 12 'AVM' groups under the Hazmat/Corp categorical separation method; and again using the 9 'Size' groups and 9 'AVM' groups using the For-hire/Private/Exempt categorical separation method. The frequency estimates for these different data breakouts are shown in Appendix B. Average yearly inspection frequencies are calculated for each group, along with a version of this statistic that is normalized by the average vehicle mileage (in millions of miles) of the group. Other statistics included are the sample size and the total number of inspections in the group for a typical year.

Another statistic calculated for each group was the ratio of fixed site inspections to roving site (a mobile inspection unit) inspections. This parameter, called the F/R index, gives a rough indication of the mix of site types, fixed or roving, involved in inspections for groups of carriers in this analysis. For example, an F/R index = 1 indicates that fixed sites and roving sites are equally represented in the calculation of a given inspection frequency. An F/R index under 1 indicates an inspection frequency due more to roving site inspections; an F/R index over 1 indicates an inspection frequency due more to fixed site inspections.

The following pages show a tabulation of the results.

Method 1: Hazmat/Corp variables

1. Grouping by AVM parameter:

Group	*# of carriers*	*Total # of insp.s / year*	*Avg. # insp.s per year*	*Avg. # insp.'s per yrly. million veh. miles*	*F/Rindex*
Non-Corp/Non-HM					
Low-miles(1001)	312	222	0.71	**65.2**	0.88
Med.-miles(1002)	456	765	1.68	**43.8**	1.32
High-miles(1003)	606	1757	2.90	**31.5**	1.46
Corp/Non-HM					
Low-miles(2001)	541	528	1.16	**128.8**	0.91
Med.-miles(2002)	619	1114	1.80	**71.2**	1.10
High-miles(2003)	777	6270	8.07	**101.0**	1.58
Non-Corp/HM					
Low-miles(1101)	9	36	3.97	**238.1**	1.95
Med.-miles(1102)	8	13	1.56	**54.8**	1.27
High-miles(1103)	20	24	12.20	**173.2**	1.68
Corp/HM					
Low-miles(2101)	91	523	5.75	**512.0**	0.83
Med.-miles(2102)	101	470	4.67	**133.8**	1.20
High-miles(2103)	128	6640	51.87	**226.0**	1.77

2. Grouping by Size parameter:

Group	*# of carriers*	*Total # of insp.s / year*	*Avg. # insp.s per year*	*Avg.# insp.'s per yrly. million veh. miles*	*F/R index*
Non-Corp/Non-HM					
Small(1001)	586	591	1.01	**16.4**	1.55
Medium(1002)	140	147	1.05	**22.6**	1.11
Large(1003)	648	2009	3.10	**59.0**	1.34
Corp/Non-HM					
Small(2001)	651	742	1.14	**26.2**	1.23
Medium(2002)	505	889	1.76	**51.6**	1.39
Large(2003)	781	6381	8.17	**171.8**	1.46
Non-Corp/HM					
Small(1101)	11	12	1.05	**20.4**	1.39
Medium(1102)	10	17	1.73	**38.2**	0.94
Large(1103)	16	263	16.47	**343.0**	1.78
Corp/HM					
Small(2101)	101	117	1.16	**30.9**	1.07
Medium(2102)	99	416	4.21	**100.0**	1.46
Large(2103)	120	7100	59.17	**958.0**	1.66

Method 2: classification For-hire/Private/Exempt

3. Grouping by AVM parameter:

Group	*# of carriers*	*Total # of insp.s / year*	*Avg. # insp.s per year*	*Avg. # insp.'s per yrly. million veh. miles*	*F/Rindex*
For-hire					
Low-miles(1001)	226	719	3.18	**154.3**	1.41
Med.-miles(1002)	369	3615	9.80	**172.5**	1.65
High-miles(1003)	421	8880	21.09	**185.0**	1.79
Private					
Low-miles(2001)	1471	2151	1.46	**99.1**	0.87
Med.-miles(2002)	365	740	2.03	**39.5**	1.07
High-miles(2003)	74	372	5.03	**23.0**	1.16
Exempt					
Low-miles(1101)	168	291	1.74	**86.5**	1.95
Med.-miles(1102)	233	495	2.12	**37.2**	1.27
High-miles(1103)	204	493	2.42	**22.0**	1.68

2. Grouping by Size parameter:

Group	*# of carriers*	*Total # of insp.s / year*	*Avg. # insp.s per year*	*Avg.# insp.'s per yrly. million veh. miles*	*F/R index*
For-hire					
Small(1001)	275	450	1.64	**19.6**	1.64
Medium(1002)	318	996	3.13	**51.6**	1.57
Large(1003)	423	11768	27.82	**375.5**	1.74
Private					
Small(2001)	535	424	0.80	**22.4**	1.16
Medium(2002)	761	769	1.01	**37.3**	1.11
Large(2003)	614	2071	3.37	**120.6**	0.84
Exempt					
Small(1101)	316	287	0.91	**13.0**	1.45
Medium(1102)	289	993	3.44	**57.9**	1.24
For-hire/Private					
All(2100)	63	233	3.68	**66.7**	1.50

Appendix C

OOS violations by category among AVM groups

Grouping the OOS violations found in the roadside inspection dataset into 14 subsets across three general categories (Driver, Vehicle, and Hazmat), the most common OOS violatios were identified in each category. The OOS violation subsets are shown below.

Driver OOSs

1. Licensing Problems
2. Physical Ailments and General Operation (392.2) Problems
3. Drugs and Alcohol
4. Record of Duty Problems

Vehicle OOSs

1. Brake-related
2. Coupling Devices
3. Exhaust/Fuel Systems
4. Lighting Devices
5. Steering/Suspension/Wheels/Rims
6. Safe Loading
7. Tires (and Miscellaneous)

Hazmat OOSs

1. Truck and Shipping Papers
2. Placarding & Markings on containers and tanks
3. Cargo Tanks/Loading and Securement/Radioactive levels

Approach 1 This approach has the viewpoint that a single inspection may have several OOS violations as an outcome. In other words we are counting OOS *violations*.

Approach 2 This approach views each inspection as having only one possible OOS outcome, where each OOS violation cited in the inspection report is given fractional credit for cause. This credit is distributed among the three major categories: Driver, Vehicle and Hazmat.

Observations of Approach

The results of taking either Approach 1 or Approach 2 are extremely similar, suggesting very few inspections result in OOS violations in two or more categories (i.e., both driver and vehicle OOS violations that lead to the OOS event). There are no significant differences in the calculated percentage of OOS's that are Driver, Vehicle or Hazmat and the Vehicle-to-Driver OOS ratio (V/D ratio):

	Driver	*Vehicle*	*Hazmat*	*V/D ratio*
Approach 1:	22%	78%	0.8%	3.6
Approach 2:	27%	72%	0.8%	2.6

The following pages show a tabulation of the results.

1. Using Hazmat/Corp category groups

NonHazmat/NonCorp/Low Miles(**1001**) .... 251 OOS violations .....4.7 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	20	14	0	66				44
Vehicle(%):	45	1	1	14	26	3	9	207
Hazmat(%):	0	0	0					0

NonHazmat/NonCorp/Med. Miles(**1002**) .... 1001 OOS violations .....5.8 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	6	11	2	81				147
Vehicle(%):	54	2	2	11	18	4	9	854
Hazmat(%):	0	0	0					0

NonHazmat/NonCorp/High Miles(**1003**) .... 2039 OOS violations .....3.8 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	3	8	1	89				424
Vehicle(%):	57	1	2	12	19	3	6	1615
Hazmat(%):	0	0	0					0

NonHazmat/Corp/Low Miles(**2001**) .... 620 OOS violations .....6.2 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	17	8	3	71				86
Vehicle(%):	46	1	2	19	16	11	5	531
Hazmat(%):	1	0	0					3

NonHazmat/Corp/Med. Miles(**2002**) .... 1176 OOS violations .....4.9 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	9	7	5	80				198
Vehicle(%):	52	1	3	16	14	4	9	970
Hazmat(%):	38	50	12					8

NonHazmat/Corp/High Miles(**2003**) .... 8360 OOS violations .....3.6 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	2	7	2	90				1800
Vehicle(%):	53	1	2	14	18	6	6	6553
Hazmat(%):	29	71	0					7

Hazmat/NonCorp/Low Miles(**1101**) ....65 OOS viol. samples .....6.2 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	0	0	0	100				9
Vehicle(%):	59	0	2	2	34	0	4	56
Hazmat(%):	0	0	0					0

Hazmat/NonCorp/Med. Miles(**1102**) ....8 OOS viol. samples .....7.0 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	0	0	0	100				1
Vehicle(%):	29	0	0	14	43	0	14	7
Hazmat(%):	0	0	0					0

Hazmat/NonCorp/High Miles(**1103**) .... 280 OOS viol. samples .....2.9 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	6	10	3	87				71
Vehicle(%):	48	1	3	10	31	1	6	208
Hazmat(%):	0	100	0					1

Hazmat/Corp/Low Miles(**2101**) .... 402 OOS viol. samples .....3.4 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	19	10	3	67				88
Vehicle(%):	40	1	3	24	17	7	9	295
Hazmat(%):	32	37	32					19

Hazmat/Corp/Med.Miles(**2102**) .... 645 OOS viol. samples .....7.7 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	8	8	1	82				72
Vehicle(%):	52	1	1	16	19	3	7	557
Hazmat(%):	44	19	38					16

Hazmat/Corp/HighMiles(**2103**) .... 8968 OOS viol. samples .....3.4 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	2	4	2	92				2204
Vehicle(%):	53	1	2	16	18	2	7	6646
Hazmat(%):	7	47	47					118

2. Using For-hire/Private/Exempt classifications

For-hire/Low Miles(**1001**) .... 115 OOS violations .....2.3 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	11	11	0	77				35
Vehicle(%):	49	0	0	16	23	3	10	80
Hazmat(%):	0	0	0					0

For-hire/Med. Miles(**1002**) .... 969 OOS violations ..... 4.2V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	6	11	2	81				187
Vehicle(%):	50	1	1	16	19	6	8	779
Hazmat(%):	33	67	0					3

For-hire/High Miles(**1003**) .... 17118 OOS violations .....3.12 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	2	5	2	91				4130
Vehicle(%):	53	1	2	15	19	4	7	12890
Hazmat(%):	6	56	38					98

Private/Low Miles(**2001**) .... 186 OOS violations ..... 3.9 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	5	3	5	87				38
Vehicle(%):	43	0	4	30	13	5	5	148
Hazmat(%):	0	0	0					0

Private/Med. Miles(**2002**) .... 1866 OOS violations .....6.9 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	20	11	5	64				233
Vehicle(%):	46	1	2	19	16	9	7	1611
Hazmat(%):	41	36	23					22

Private/High Miles(**2003**) .... 755 OOS violations .....7.5 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	10	8	0	82				89
Vehicle(%):	60	2	2	15	12	4	6	665
Hazmat(%):	0	0	100					1

Exempt/Low Miles(**1101**) ....63 OOS viol. samples .....5.3 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	0	0	0	100				10
Vehicle(%):	51	2	0	26	21	0	4	53
Hazmat(%):	0	0	0					0

Exempt/High Miles(**1102**) ....449 OOS viol. samples .....7.8 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	12	10	2	76				50
Vehicle(%):	55	1	2	10	23	2	7	389
Hazmat(%):	0	0	0					0

Exempt/High Miles(**1103**) .... 875 OOS viol. samples .....4.1 V/D ratio

Categories	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**#smpls**
Driver (%):	1	5	2	92				172
Vehicle(%):	54	2	2	9	21	2	9	703
Hazmat(%):	0	0	0					0

Appendix D

Site-based Analysis of Roadside Inspection Data

Approach

We would like to know if the OOS rate at a fixed site for a given carrier is site-independent or site-dependent. In other words, we seek an answer to the question: *Does a carrier's OOS rate vary much across different inspection sites?* The answer 'yes' to this question would indicate a lack of uniformity in the vehicle selection process at fixed inspection sites and/or individual interpretation of the OOS criteria. A 'no' answer indicates uniform biases in the vehicle selection process and uniform adherence to OOS criteria. The chosen statistical framework for a particular 'fixed' site, expressed in terms of probabilities, is as follows:

Prob [OOS viol.] = Prob [inspection] * Prob [vehicle in poor cond]

or A = B * C

We measure A from RI data at a selected site and is essentially the OOS rate. B and C are unknown to us, however, we do have some information about these two quantities. From common sense deductions, we can say that C is both site-independent and carrier-dependent. Also, we have indications from preliminary analyses on RI data that B is *carrier*-dependent (higher inspection rates for larger carriers), but we do not know whether B is site-dependent or not. The OOS rates from the two most commonly encountered fixed sites have been produced for five different carriers from RI data (Figure 3.2). The OOS rate for the same carrier is compared at these two sites and, if similar, then B (above) can be considered site-independent.

Results

The statistics gathered from the five carriers in question are shown in Figure 3.2. The OOS rate calculated from all movable sites is also included for comparison. Since the OOS rates do not vary widely from site to site for a given carrier, we suggest that, in general, B (above) is site-independent, and therefore we can assume that *uniform* biases exist in the vehicle selection process from site to site and from state to state. Another way to say this is that the probability of a particular carrier's vehicles being selected for inspection is constant from one inspection site to the next. This determination appears plausible at least for carriers we've attempted to identify as having predominantly large long-haul types of operations, since they are least likely to avoid the major weigh stations accommodating fixed sites. Finally, these results were obtained by analyzing well-inspected carriers and suggest that the most accurate estimate of a carrier's OOS rate is obtained when its vehicles/drivers are inspected with regularity.

CARRIER #212726 (member of Hazmat/Corp/Long haul --2103)

	# of Samples	OOS rate
site 676 (MNHRBRG)	53	0.45
site 772 (MNSTCRX)	77	0.52
all 'movable' sites	512	0.22

CARRIER #204273 (member of NonHazmat/Corp/Long haul --2003)

	# of Samples	OOS rate
site 676 (MNHRBRG)	30	0.37
site 772 (MNSTCRX)	73	0.41
all 'movable' sites	57	0.25

CARRIER #139992 (member of NonHazmat/Corp/Short haul --2001)

	# of Samples	OOS rate
site 653 (MNERSKN)	20	0.15
site 755 (MNSGNAW)	62	0.26
all 'movable' sites	128	0.28

CARRIER #467890 (member of NonHazmat/NonCorp/Medium haul --1002)

	# of Samples	OOS rate
site 653 (MNERSKN)	46	0.17
site 755 (MNSGNAW)	67	0.29
all 'movable' sites	37	1.00

CARRIER #381882 (member of NonHazmat/Corp/Short haul --2001)

	# of Samples	OOS rate
site 653 (MNERSKN)	43	0.00
site 755 (MNSGNAW)	13	0.07
all 'movable' sites	8	0.00

Figure D-1 Site-based Inspection Data (Haul_distance groups)

Below, in Table D-1, a comparison of the OOS rates at the Minnesota-administered 'St Croix' scale and the Wisconsin-administered 'Hudson' scale shows that the OOS rates of the same carriers at both sites are similar (4 of 5 cases). Although this comparison was made between just two major *fixed* inspection sites, this result suggests that inspectors at the roadside in Minnesota and Wisconsin conduct vehicle inspections in a comparable way. The similarity in OOS rates at these two scales is expected since it is likely that states participating in MCSAP Roadside Inspection activities will adopt the recommendations of the Commercial Vehicle Safety Alliance regarding inspection criteria/procedures to discover OOS violations.

Table D-1 Comparison of OOS Rates at St Croix (MN) vs. Hudson (WI) Scales

Carrier (DOT #)	St Croix scale OOS rate (# samples)	Hudson scale OOS rate (# samples)
75525	0.36(43)	0.45(220)
116415	0.34(101)	0.43(19)
204273	0.20(14)	0.38(77)
212273	0.53(15)	0.41(30)
246865	0.39(13)	0.47(37)

Appendix E

Factor Score Analysis of CR Data

There are six *factors* that influence the outcome (the overall rating) of a Compliance (or Safety) Review. These factors cover specific aspects of a carrier's compliance with the Federal Highway Administration's safety regulations that concern motor carriers. The six regulatory factors, which can be graded as satisfactory (S), conditional (C) or unsatisfactory (U), are listed below:

factor	*Description*
1.	General regulations
2.	Driver regulations
3.	Operational regulations
4.	Vehicle regulations
5.	HazMat regulations
6.	Accident Factor = Recordable Preventable Accident Rate

During a carrier's review, each of these factors are evaluated and given a rating of S,C, or U. The formula below is used to determine the overall safety rating.

Factor Ratings		*Overall Safety Rating*
Unsatisfactory	Conditional	
0	2 or less	Satisfactory
0	more than 2	Conditional
1	2 or less	Conditional
1	more than 2	Unsatisfactory
2 or more	more than 0	Unsatisfactory

Objective

We seek an answer to the question: which factors of the Compliance review contribute most to an overall rating that is not Satisfactory? Clearly, from the above rule, factors that are individually rated U or C influence both overall outcomes of U or C. Therefore, the first objective is to discover, from data, those factors that are rated Conditonal (C) most frequently, and those factors that are rated Unsatisfactory (U) most frequently. A second objective is to determine how these frequencies differ among carriers with different characteristics.

Approach

In the delivered form of the CR dataset, there were a total of 2473 carriers that received reviews during the years 1992 - 1995. Of these carrier's, 1766 carriers received an overall satisfactory rating, 550 received an overall conditional rating, and only 157 carrier's received an overall unsatisfactory rating.

This analysis has utilized the grouping strategy that focuses on the Hazmat/Corp variables together with 'AVM' characterization of carriers. Further, because of so much similarity in the results, the 12 original groups were combined into these four supersets:

1. Non-Hazmat/Low-miles
2. Non-Hazmat/Med.-miles
3. Non-Hazmat/High-miles
4. All Hazmat

Results

Results of this analysis are found on the following pages in tabular form. Only CRs (or SRs) with outcomes of unsatisfactory or conditional are considered in each of the four supersets above (722 carriers from 1992-1995). In a specific superset, each factor is ranked according to its frequency of being rated unsatisfactory among those factors rated unsatisfactory, and according to its frequency of being rated conditional among those factors rated conditional. The numerical weight listed under each ranked factor is that factor's relative frequency of occurance among all factors rated the same within that superset, i.e. these weights should not be considered as an *overall* occurance rate in the dataset. Factors having weights below 0.06 were neglected.

1. **Non-Hazmat/Low-miles**

Unsatisfactory (149 samples)

Rank	*1*	*2*	*3*
Factor	2	3	4
(weight)	.53	.33	.12

Conditional (320 samples)

Rank	*1*	*2*	*3*	*4*
Factor	4	2	3	1
(weight)	.33	.30	.21	.15

2. Non-Hazmat/Med.-miles

Unsatisfactory (131 samples)

Rank	*1*	*2*	*3*
Factor	2	3	4
(weight)	.45	.39	.15

Conditional (305 samples)

Rank	*1*	*2*	*3*	*4*
Factor	2	4	3	1
(weight)	.41	.26	.16	.14

3. Non-Hazmat/High-miles

Unsatisfactory (159 samples)

Rank	*1*	*2*	*3*
Factor	3	2	4
(weight)	.54	.32	.13

Conditional (360 samples)

Rank	*1*	*2*	*3*	*4*	*5*
Factor	2	4	3	6	1
(weight)	.44	.25	.10	.10	.10

4. All Hazmat carriers

Unsatisfactory (15 samples)

Rank	*1*	*2*	*3*
Factor	3	2	6
(weight)	.53	.40	.06

Conditional (47 samples)

Rank	*1*	*2*	*3*	*4*
Factor	6	2	4	1
(weight)	.28	.25	.23	.15