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Impact of federal compliance reviews of trucking companies in reducing highway truck crashes☆

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Abstract

Background: The compliance review (CR) is a federal program monitoring motor carrier safety performance and regulatory compliance. This study sought to assess the impact of CRs on reviewed trucking companies in reducing truck crashes.

Methods: Data was from the Motor Carrier Management Information System. Study subjects were trucking companies established during 1990–1995, had at least one truck, and remained active until April 2004. Truck crash data of these companies was examined from 1996 to 2003. The crash rates in 2003 and annual percentage changes in number of crashes were computed. Analyses were stratified by company size, organization, operation classification, and safety rating.

Results: Companies that received CRs had a higher crash rate than never-reviewed companies. Reviewed companies experienced a 39–15% reduction in number of crashes in the year the CR was performed. The reduction in crashes was observed in all reviewed companies regardless of company size, operation classification, type of organization, or safety rating. The reduction in crashes was sustained for at least 7 years after CRs.

Discussion: The study results were controlled for the year in which CRs were performed, crash trend, and CR selection bias. However, further studies, especially a randomized prospective longitudinal study, are needed to overcome the limitations that are associated with an observation study.

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Keywords: Truck crash; Truck safety; Compliance review; Evaluation

1. Introduction

The compliance review (CR) is a US federal program to assess safety performance and regulatory compliance of motor carriers' operation. The Federal Motor Carrier Safety Administration (FMCSA) administers the CR program. FMCSA primarily uses Safety Status Measurement System (SafeStat) to identify motor carriers for a CR. A small portion of the total motor carrier population is selected for a CR every year. SafeStat is an automated analysis system combining current and historical safety performance data to measure the relative (peer-to-peer) safety fitness of interstate commercial motor carriers (FMCSA, 2007a). SafeStat enables the FMCSA to quantify and monitor the safety status of motor carriers and guides the deployment of resources to focus on carriers posing the greatest safety risk.

CRs consist of an on-site examination of a motor carrier's operations including: driver's hours of service, vehicle maintenance/inspection, driver qualification, controlled substance and alcohol testing, commercial driver's license requirements, financial responsibilities, accidents, hazardous material, and compliance with commercial/economic regulations (if applicable). A CR takes one safety investigator an average 3–4 days to complete. The CR program is the single greatest resource-consuming activity in FMCSA (FMCSA, 2005). A more-detailed description of how carriers are selected for a CR and how CRs are administered can be found on the FMCSA's website of "What is a compliance review?" (FMCSA, 2007b).

A goal of CRs is to determine whether a motor carrier meets the Section 385.5 Safety Fitness standards (FMCSA, 2006). After a CR is completed, one of the following three safety ratings

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is issued to the reviewed carrier: (1) satisfactory, (2) conditional satisfactory, or (3) unsatisfactory. For a carrier receiving a conditional satisfactory or unsatisfactory rating, corrective actions are required within 30 days or the carrier's operating authority will be revoked and an operating out of service will be imposed prohibiting the carrier from operating any motor vehicle in the U.S. A follow-up review may be conducted to ensure that all necessary corrective actions have been taken. There are also some indirect economic disadvantages to the carriers who received an unsatisfactory or conditional satisfactory rating. For example, some large shippers, such as the Chrysler Corporation and the Department of Defense, have polices of contracting only with motor carriers who have been rated "satisfactory" in CRs (Moses and Savage, 1992).

A major expected benefit of CRs is to improve the level of safety operation of motor carriers. The effectiveness or impact of CRs in the improvement of motor carriers' safety operation has been evaluated in two previous studies. The first study (Moses and Savage, 1992) used data from the Motor Carrier Management Information System (MCMIS) and examined 13,053 motor carriers that received CRs between October 1986 and July 1989. The Moses and Savage study suggested that re-inspections of previously reviewed carriers showed the improvement in safety performance occurred only in carriers that received the unsatisfactory rating. Moses and Savage concluded that the CR program did not appear to have resulted in a detectable improvement in the accident rate of the industry, because only a few companies received unsatisfactory ratings. The second study, by FMCSA and the Volpe Transportation Center (FMCSA, 2005), compared crash rates 12 months before CRs and 12 months after CRs among motor carriers that received CRs in 2002. The FMCSA study suggested motor carriers that received CRs in 2002 experienced a 13% reduction in crash rates during the 12 months following CRs. Small carriers had a greater reduction in crash rate compared to large carriers. The FMCSA study estimated 1426 police-reported crashes, 1087 injuries, and 62 fatalities were prevented during the 12 months following the implementation of CRs among the 9172 carriers that received CRs in 2002.

However, the FMCSA study did not differentiate trucking companies from bus companies. It did not break down carriers by organization, operation classification, or safety rating. Hence, it was not clear whether the positive impact of CRs occurred in all reviewed carriers or only in a sub-group of the reviewed. For example, the Moses and Savage study suggested that CRs only improved safety performance in reviewed carriers that received the unsatisfactory rating. The FMCSA study only observed crash data 12 months before and after CRs. The crash trend over the years before and after CRs was not examined. The long-term impact of CRs on reviewed carriers was not studied.

The objectives of this study were to assess: (1) whether CRs were associated with a reduction in number of crashes in reviewed trucking companies, (2) whether the reduction occurred in every sub-group of reviewed trucking companies, and (3) whether the reduction in crashes was sustained over time following CRs.

2. Methods

2.1. Databases and study population

Two Motor Carrier Management Information System (MCMIS) files were used for the study: MCMIS census file and crash file. MCMIS is a computerized system whereby FMCSA maintains a comprehensive record of for-hire, private property, and passenger carriers subject to the Federal Motor Carrier Safety Regulations or Hazardous Materials Regulations. The census file contains data on carriers' names, addresses, types of organizations (e.g., corporation, partner, and individual), operation classifications (e.g., for-hire, private, government, etc.), entity types (e.g., carrier, shipper, both carrier and shipper, and registrant), number of vehicles, and number of commercial drivers. It also contains data on the dates of CRs performed and the safety ratings assigned to the companies. If a company received multiple CRs, only the most recent CR is kept in the MCMIS census file. The crash file contains data from State Police crash reports involving a truck or a bus of motor carriers operating in the United States. The inclusion criteria for reportable crashes are crashes that resulted in at least one fatality, injury, or vehicle towed away from the scene as a result of disabling crash damage.

To control the years of experience of trucking companies which is a risk factor associated with safety performance (Moses and Savage, 1994), the study subject selection criteria were trucking companies established (or added to the MCMIS census file) during 1990–1995, had at least one truck, and remained active until April 2004. Of these trucking companies, those who received CRs during 1996–2003 served as intervention groups, those who never received CRs served as a reference group, and those who received CR before 1996 were excluded from the study because no crash data was available before 1996. Trucking companies that received CRs in the same year were grouped together and treated as an annual cohort (or group). As a result, there were eight annually reviewed groups (i.e., one for each year from 1996 to 2003) and a never-reviewed reference group in the study.

The observation variable was the number of truck crashes. A truck is defined as a vehicle designed, used, or maintained primarily for carrying property that has at least two axles and six tires. Crashes involving dump trucks and garbage/refuse trucks were excluded from the study because these trucks might have different travel patterns than other trucks.

2.2. Statistical techniques

A logistical regression was used to assess the characteristics of the trucking companies that received unsatisfactory or conditional satisfactory ratings. The regression had the form: safety rating = company size + operational classification + organization + year of receiving CR, where safety rating had two values: 1 for satisfactory and 2 for unsatisfactory or conditional satisfactory.

To estimate the association between CRs and a reduction in crashes, crash rates in 2003 were computed for each group and

presented as the number of crashes per 100 trucks. Crash rates were not computed for the years before 2003 because data on the number of trucks prior to 2003 was not available. In addition, the annual percentage change in number of crashes was computed by year and by group using the formula: PCNT = $(A - B)/B$, where PCNT = annual percentage change, A = the number of crashes in year (i), B = the number of crashes in year ($i - 1$). The average annual percentage change was then computed for the following categories: (1) average of all the reviewed groups in the year of receiving CRs (or the CR year), (2) average of all the reviewed groups in the years before the CR year, (3) average of all the reviewed groups in the years after the CR year, and (4) average of the 1996–2003 time period for the never-reviewed group.

A regression model was used to adjust for potential confounding factors due to the group effect (different group received CRs in different year) and the crash trend in a reference group. The regression model had the form: ADJPCNT = GROUP + $\alpha \times$ DIFYR, where GROUP is the annual reviewed group, α is the adjusted average annual percentage change in the number of crashes in the years before or after CR, and DIFYR is the difference in the numbers of years from the observation year to the year before receiving CRs. For example, for the group that received CRs in 2000, DIFYR = 0 in 1999, DIFYR = 1 in 2000, and DIFYR = −1 in 1998, etc. Two separate runs of the regression model were carried out: one for negative DIFYRs and the other for positive DIFYRs.

The dependent variable in the regression model ADJPCNT, the adjusted annual percentage change in number of crashes, was computed by using the following formula: $\text{ADJPCNT} = (\text{ADJN}_{(i)} - \text{ANJN}_{(i-1)})/\text{ADJN}_{(i-1)}$, where ADJN is the adjusted number of crashes, which is adjusted for the crash trend in a reference group. ADJN was calculated by using the formula: $\text{ADJN}_{(ij)} = N_{(ij)} \times (\text{RN}_{(96)}/\text{RN}_{(i)})$, where $\text{ADJN}_{(ij)}$ is the adjusted number of crashes in year (i) for group (j), $N_{(ij)}$ is the number of crashes in year (i) for group (j), RN_{96} is the number of crashes in 1996 for the reference group, and $\text{RN}_{(i)}$ is the number of crashes in year (i) for the reference group. For example, using the never-reviewed group as a reference, the adjusted number of crashes in 1998 for the 1999 group = $725 \times (4130/3809) = 786$, where 725 is the number of crashes in 1998 for the 1999 group, 4130 is the number of crashes in 1996 for the never-reviewed group, and 3809 is the number of crashes in 1998 for the never-reviewed group (see Table 3 for these numbers).

In addition to the never-reviewed group, the group that received CRs in 2003 was also used as a reference. The 2003 group did not have CRs until 2003, and thus, served as a second reference for the time period from 1996 to 2002. The benefit of using the 2003 group as a reference was to adjust for potential confounding factors due to CR selection bias. Companies selected for CRs were different from companies that never received CRs in terms of company size, organization, operation classification, and safety performance. The 2003 group would be more comparable on these factors with the other reviewed groups than would the never-reviewed reference group.

Analyses were stratified by company size, organization, operation classification, and safety rating. Company size was categorized into three groups; companies with 1–6, 7–20, and 21 or more trucks. Company organization was categorized into three groups: individual, partnership, and corporation companies. Company operation classification was categorized into three groups: authorized for-hire, private, and others. When reporting to the MCMIS census file, a trucking company may report multiple classifications (e.g., both for-hire and private). In this study, the group of for-hire included companies that were only for-hire and the group of private included companies that were private only. Companies that were both for-hire and private were included in the "Others" category.

3. Results

According to the April 2004 MCMIS census file, there were 145,002 trucking companies that were established in 1990–1995, had at least one truck, and remained active until April 2004. Of these companies, 9592 received CRs during 1996–2003, 109,736 never received CRs, and 25,674 received CRs before 1996. This study included the 9592 companies that received CRs during 1996–2003 and the 109,736 companies never reviewed.

The number of trucking companies that received CRs varied each year. However, there was an increase trend from 1997 to 2003 (Table 1). Of the reviewed companies, 76% got satisfactory and 24% got unsatisfactory or conditional satisfactory safety ratings. However, small, individual/partnership, or private trucking

Table 1
The number of trucking companies that received compliance reviews (CRs) and safety ratings by year

Year	Number of companies received CRs	Safety ratings		
		Satisfactory (row %)	Conditional satisfactory (row %)	Unsatisfactory (row %)
1996	1,406	912 (65)	342 (24)	152 (11)
1997	181	124 (69)	36 (20)	21 (12)
1998	629	443 (70)	158 (25)	28 (4)
1999	946	720 (76)	189 (20)	39 (4)
2000	1,462	1,148 (79)	260 (18)	54 (4)
2001	1,297	1,090 (84)	197 (15)	5 (0)
2002	1,677	1,376 (82)	294 (17)	7 (0)
2003	1,999	1,503 (75)	483 (24)	13 (1)
Total	9,592	7,316 (76)	1,959 (20)	317 (3)

Table 2
Logistic regression results of the characteristics of the trucking companies that received conditional satisfactory or unsatisfactory safety rating

Company characteristics	Odd ratio[a]	95% CI[b]
Company size		
One to six trucks vs. 21 or more trucks	1.6	1.3–1.8
7–20 trucks vs. 21 or more trucks	1.5	1.3–1.8
Company organization		
Corporation vs. individual/partnership	0.86	0.76–0.97
Company operation classification		
For-hire vs. private	0.78	0.7–0.87
Others vs. private	1.1	1.0–1.3
Review year (1 year incremental from 1996 to 2003)	0.92	0.9–0.94

[a] Odds ratios greater than 1 suggest more likely to get conditional satisfactory or unsatisfactory safety rating.
[b] Confidence interval.

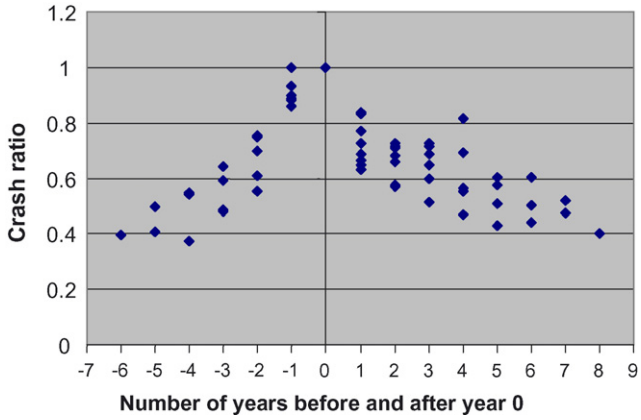

Fig. 1. Cash ratio by the number of years before and after CRs. Crash ratio was calculated by using the crash data on Table 3 and the following formula: crash ratio = the number of crashes in year *i* for group *j*/the number of crashes in the year 0 (the year before the CR year was defined as year 0) for the same group. For example, for the group reviewed in 1997 the number of crashes in year 0 (1996) = 123, the number of crashes in year 1 (1997) is 75, ratio for year 1 = 75/123 = 0.61.

companies were more likely to get unsatisfactory or conditional satisfactory than their counterparts—large, cooperation, or for-hire trucking companies, respectively (Table 2).

The reviewed groups had a higher crash rate in 2003 than the never-reviewed reference group (Table 3). Among the reviewed groups, there was a linear relationship between the crash rate in 2003 and the year in which a group received CRs; the 1996 group had the lowest rate and the 2003 group had the highest. In general, the number of crashes increased over the years before CRs and decreased over the years after CRs (Table 3 and Fig. 1). Table 4 presents the annual percentage change in number of crashes by group and by year, which was derived from the data on number of crashes in Table 3. There was a significant decrease in the number of crashes during the CR year in every reviewed group. However, there was a decreased trend in degree of the reduction from the 1996 group a 39% reduction to the 2003 group a 15% reduction (Table 4, the diagonal cells in grey).

The number of crashes in the never-reviewed reference group decreased on average 1.5% annually during 1996–2003 (Table 5). In contrast, the number of crashes among the reviewed groups: (1) increased on average 19.2% annually in the years before the CR year (average of all cells above the diagonal cells in Table 4); (2) decreased on average 27.2% in the CR year (average of all the diagonal cells); and (3) decreased on average 4.3% annually in the years after the CR year (average of all cells below the diagonal cells in Table 4). Similar crash experiences were observed in all sub-groups of trucking companies by size, organization, operation classification, or safety rating.

Table 6 presents the adjusted average annual percentage changes in the number of crashes in the years before and after the CR year. Similar to the unadjusted in Table 5, the adjusted average annual percentage changes also indicated a reduction in number of crashes in the years after CR and an increase in number of crashes in the years prior to CR. Using the 2003 group as a reference yielded a greater reduction in number of crashes than using the never-reviewed group as a reference. For example, in the private company group, no significant change was observed in the unadjusted average annual percentage change in the years after CR (Table 5) or the adjusted change using the never-reviewed group as a reference. However, a significant decrease was observed in the adjusted change using the 2003 group as a reference (Table 6).

Table 3
Number of truck crashes by year and group, and crash rates in 2003 by group

Year	Group reviewed in 1996	Group reviewed in 1997	Group reviewed in 1998	Group reviewed in 1999	Group reviewed in 2000	Group reviewed in 2001	Group reviewed in 2002	Group reviewed in 2003	Group never reviewed
1996	414	123	472	434	626	560	709	888	4,130
1997	355	75	517	687	844	673	886	1,035	3,881
1998	311	82	337	725	1,055	839	942	1,121	3,809
1999	275	75	347	479	1,145	1,196	1,153	1,279	3,679
2000	285	58	336	440	912	1,272	1,474	1,430	3,523
2001	282	45	384	435	783	926	1,483	1,683	3,533
2002	277	48	278	393	826	747	1,183	1,968	3,647
2003	238	57	298	426	800	802	1,060	1,674	3,704
2003 crash rate[a]	1.68	2.24	2.82	3.04	2.99	3.08	3.34	4.72	1.07

Shaded cells represent the years before the CR year.
[a]Crash rate was calculated as the number of crashes per 100 trucks.

Table 4
Yearly percentage change in number of truck crashes[a] by group and year

Year	Group reviewed in 1996	Group Reviewed in 1997	Group Reviewed in 1998	Group Reviewed in 1999	Group Reviewed in 2000	Group Reviewed in 2001	Group Reviewed in 2002	Group Reviewed in 2003	Group never reviewed
1996	----	----	----	----	----	----	----	----	----
1997	-14.3	-39.0	9.5	58.3	34.8	20.2	25.0	16.6	-6.0
1998	-12.4	9.3	-34.8	5.5	25.0	24.7	6.3	8.3	-1.9
1999	-11.6	-8.5	3.0	-33.9	8.5	42.6	22.4	14.1	-3.4
2000	3.6	-22.7	-3.2	-8.1	-20.3	6.4	27.8	11.8	-4.2
2001	-1.1	-22.4	14.3	-1.1	-14.1	-27.2	0.6	17.7	0.3
2002	-1.8	6.7	-27.6	-9.7	5.5	-19.3	-20.2	16.9	3.2
2003	-14.1	18.8	7.2	8.4	-3.1	7.4	-10.4	-14.9	1.6

Shaded (diagonal) cells represent the CR year; the cells above the diagonal represent the years before the CR year; the cells below the diagonal represent the years after the CR year.

[a] Yearly percentage change in number of crashes was calculated by using the crash data on Table 3 and the following formula: Yearly percentage change in year (i) = [(number of crashes in year (i) − number of crashes in year $(i-1)$)/number of crashes in year $(i-1)$] × 100%. For example, the yearly percentage change for the 1996 group in 1997 = ((355 − 414)/414) × 100% = −14.3%.

4. Discussion

This study suggests that the CR program had a strong impact soon after completion of CRs in reducing truck crashes. The reduction in number of crashes was sustainable, although the degree of the reduction was smaller in the years after the CR year than the reduction in the CR year. The reduction can be observed in all reviewed trucking companies regardless of company sizes, operation classifications, organizations, or safety ratings.

When interpreting the study results, several possible limitations should be noted. One possible limitation is that the companies selected for CRs may not be a representative sample of the general trucking company population and could possibly have a higher risk of crashes than the general population. This observation study could not separate the effects of CRs from the effect of regression to the mean (RTM). Extreme subjects (outliers) tend to regress to the mean regardless of any intervention. Companies might be selected for CRs directly or indirectly because of "bad luck" that made them unsafe in the year before CRs. They would tend to regress to the mean in the future years just based on return to "normal luck".

However, there are three observations which could not be explained by RTM alone. (1) The number of crashes increased for many years prior to CRs for all reviewed groups. For example, the group reviewed in 2003 had an increase in number of crashes for seven continuous years before CRs in 2003. It might be reasonable to assume that the number of crashes would have continued to increase if there were not CRs for this group. (2) The degrees of the reduction in number of crashes in the CR year were similar between companies with conditional satisfactory or unsatisfactory ratings (30%) and companies with satisfactory ratings (27%). Thus, the impact of CRs was substantial on all companies regardless of their previous safety performance. (3) A greater reduction in the number of crashes was obtained by the use of the 2003 group as a reference compared to the use of the never-reviewed group as a reference. The purpose of using the 2003 group as a reference was to control potential confounding factors due to CR selection bias. The 2003 group was comparable with the other reviewed groups in terms of safety performance.

A second possible limitation is that data on the number of trucks in a trucking company prior to 2003 was not available. Crash rates could not be evaluated prior to 2003. An assumption was made that the number of trucks in each group was the same during the study time period or if there was a change, the direction of change (increase or decrease) was the same for all groups. In another words, if one group increased its number of trucks over the years, the other groups might also have had an increase in their number of trucks. There was no available evidence to suspect that one group was more likely to increase or to decrease its trucks over the years in a way that was different from the other groups, but this cannot be ruled out.

A third possible limitation is that the year when a carrier was added to the MCMIS census file did not always match the year the carrier was established. It might be the year of re-activation, re-organization, or merging in some cases. A fourth possible limitation includes that CRs do not collect data on individual trucks and truck drivers. Crash risk could not be evaluated at the level of individual driver or trucks, although they are the ones that have crashes. A final possible limitation is that the MCMIS crash files are intended to be a census of commercial trucks and buses involved in fatality, injury, or tow-away crashes. However, some states did not report all eligible crashes.

The strengths of the MCMIS database include that it contains data on all motor carriers operating in the United States. MCMIS provides a unique opportunity to study truck safety on the national level. MCMIS is an on-going surveillance system which has been used by researchers to evaluate the effectiveness of safety programs (FMCSA, 2005; Keane et al., 2002) and to assess the impact of new safety technologies in reducing truck crashes (Chen et al., 2004a,b).

It is worth noting that there were several differences in the study design between the FMCSA (2005) study and this study. The FMCSA study did not differentiate trucking companies from bus companies. This study observed trucking companies only. The FMCSA study observed crash data 12 months before and after CRs for the motor carriers reviewed in 2002. This study observed 8 years (1996–2003) of crash data for the trucking companies reviewed from 1996 to 2003. For the group reviewed in 1996 there were 7 years of crash data after the CR year; for the

Table 5
Average annual percentage changes in the number of crashes and 95% confidence interval (CI) for reviewed groups by company characteristic and three time period (in the compliance review (CR) year, the years before, and after the CR year); plus average annual percentage changes and 95% CI in 1996–2003 for the never-reviewed group

Company groups and time period	Average (%)	Low 95% CI	Upper 95% CI
All reviewed trucking companies			
In the years before the CR year (reviewed groups)	19.2	13.3	25.1
In the CR year (reviewed groups)	−27.2	−33.9	−20.5
In the years after the CR year (reviewed groups)	−4.3	−8.7	0.1
Companies with one to six trucks			
In the years before the CR year (reviewed groups	17.7	7.7	27.7
In the CR year (reviewed groups)	−49.9	−58.6	−41.1
In the years after the CR year (reviewed groups)	−12.0	−20.6	−3.4
In the 1996–2003 time period for the never-reviewed group	−4.9	−9.4	−0.4
Companies with 7–20 trucks			
In the years before the CR year (reviewed groups)	19.3	9.8	28.9
In the CR year (reviewed groups)	−38.4	−45.0	−31.8
In the years after the CR year (reviewed groups)	−7.4	−15.0	0.3
In the 1996–2003 time period for the never-reviewed group	2.0	−2.8	6.7
Companies with over 20 trucks			
In the years before the CR year (reviewed groups)	19.4	14.9	24.0
In the CR year (reviewed groups)	−12.3	−22.2	−2.5
In the years after the CR year (reviewed groups)	−0.3	−5.9	5.2
In the 1996–2003 time period for the never-reviewed group	5.2	0.1	10.2
Corporation companies			
In the years before the CR year (reviewed groups)	18.0	12.2	23.9
In the CR year (reviewed groups)	−25.2	−30.8	−19.7
In the years after the CR year (reviewed groups)	−4.3	−8.7	0.1
In the 1996–2003 time period for the never-reviewed group	−1.0	−3.0	1.0
Individual and partner companies			
In the years before the CR year (reviewed groups)	25.5	13.2	37.9
In the CR year (reviewed groups)	−42.8	−55.4	−30.2
In the years after the CR year (reviewed groups)	1.0	−16.0	17.9
In the 1996–2003 time period for the never-reviewed group	−2.7	−7.2	1.7
For-hire companies			
In the years before the CR year (reviewed groups)	18.0	12.4	23.7
In the CR year (reviewed groups)	−26.3	−33.4	−19.2
In the years after the CR year (reviewed groups)	−5.0	−9.3	−0.6
In the 1996–2003 time period for the never-reviewed group	−1.8	−5.0	1.4
Private companies			
In the years before the CR year (reviewed groups)	25.7	13.4	38.0
In the CR year (reviewed groups)	−34.1	−48.5	−19.8
In the years after the CR year (reviewed groups)	4.8	−5.6	15.3
In the 1996–2003 time period for the never-reviewed group	0.1	−4.6	4.8
Companies with conditional and unsatisfactory rating			
In the years before the CR year (reviewed groups)	25.5	16.9	34.1
In the CR year (reviewed groups)	−30.4	−41.0	−19.7
In the years after the CR year (reviewed groups)	−9.4	−19.1	0.4
Companies with satisfactory rating			
In the years before the CR year (reviewed groups)	18.1	11.5	24.7
In the CR year (reviewed groups)	−27.1	−35.0	−19.1
In the years after the CR year (reviewed groups)	−1.9	−6.1	2.2
The never-reviewed group in 1996–2003	−1.5	−4.0	1.0

group reviewed in 2003 there were 7 years of crash data before the CR year. This provided a dynamic picture of crash experience many years before and after CRs. The FMCSA study used the general carrier population as a reference. This study used two reference groups: the group never reviewed and the group reviewed in 2003. The group reviewed in 2003 might be a better reference than the general carrier population because it was comparable with the other reviewed groups in respect to safety performance.

Despite the above differences, results from both the FMCSA and this study suggest that motor carriers that were selected for a CR had a higher crash rate than the general motor carrier

Table 6
Adjusted[a] average annual percentage changes in the number of crashes and 95% confidence interval (CI) by company characteristics, and by the years before and after the compliance review (CR) year

	Adjusted average annual percentage change A[b]			Adjusted average annual percentage change B[c]		
	Average (%)	Low 95% CI	Upper 95% CI	Average (%)	Low 95% CI	Upper 95% CI
All companies that received CRs						
Before CR	7.7	4.1	11.3	3.3	0.9	5.7
After CR	−3	−4.4	−1.6	−7.2	−8.6	−5.8
By size						
Carriers with one to six trucks						
Before CR	15	12.3	17.7	4.1	−0.9	9.1
After CR	−1.7	−3.0	−0.4	−4.1	−5.7	−2.5
Carriers 7–20 trucks						
Before CR	11.4	9.0	13.8	3.6	0.4	6.8
After CR	−2.8	−4.7	−0.9	−5.7	−7.3	−4.1
Carriers with 20 trucks						
Before CR	7.8	5.3	10.3	3	0.5	5.5
After CR	−5.6	−8.3	−2.9	−8.5	−11.2	−5.8
By organization						
Corporation						
Before CR	12.2	10.3	14.1	3.1	0.8	5.4
After CR	−3.8	−5.6	−2.0	−7.5	−9.2	−5.8
Individual/partner						
Before CR	15.5	12.4	18.6	6	1.0	11.0
After CR	−1.3	−4.4	1.8	−2.7	−4.3	−1.1
By operation classification						
For-hire						
Before CR	12.2	10.5	13.9	2.7	0.7	4.7
After CR	−3.5	−5.1	−1.9	−6.7	−8.5	−4.9
Private						
Before CR	14.4	10.6	18.2	7.8	2.9	12.7
After CR	1.3	−4.6	7.2	−6	−10.1	−1.9
By safety rating						
Conditional or unsatisfactory rating						
Before CR	13.5	10.8	16.2	3.6	0.1	7.1
After CR	−3.5	−6.9	−0.1	−5.8	−8.9	−2.7
Satisfactory rating						
Before CR	12.6	10.6	14.6	3.1	0.6	5.6
After CR	−2.7	−4.3	−1.1	−7.7	−9.5	−5.9

[a] Adjusted for group effect (the year in which a group was reviewed) and crash trend in a reference group.
[b] Adjusted change A was calculated by using the never-reviewed group as a reference.
[c] Adjusted change B was calculated by using the 2003 group as a reference. The 2003 group did not have CRs until 2003 and served as a reference in 1996–2002 (see Section 2 for a detailed description).

population. Reviewed motor carriers had a significant reduction in number of crashes soon after CRs. Small carriers had a greater reduction in crashes than large carriers.

In addition, this study indicates individual/partner and private companies had a greater reduction in crashes in the CR year than corporation and for-hire companies. However, the reduction was sustained better in corporations, for-hire companies, and larger companies. It is possible that small and individual/partner companies might be able to make changes quickly. However, large or corporation companies might have more resources available to see that changes are implemented and sustained. It might also be possible that small, individual/partner, and private companies have more room to improve their safety performance. This was supported by the observation that small, individual/partner, and private companies were more likely to receive unsatisfactory or conditional satisfactory safety ratings than large, corporation, and for-hire companies. A possible explanation for the difference in safety ratings between for-hire and private companies is that safety performance is directly connected with the market share for for-hire companies, while such a connection does not exist for private companies because they haul their own cargo.

Companies with the satisfactory safety ratings had a similar reduction in crashes compared to companies with the conditional satisfactory or unsatisfactory safety ratings (27.1% versus 30.4%

reduction). This result disagrees with the Moses and Savage study (1992) which suggested CRs only improved the safety performances in carriers with the unsatisfactory ratings. The Moses and Savage study was based on the result of re-inspections of previously reviewed companies, not based on crash data. However, this study was based on crash data many years before and after CRs.

Although the degree of reduction in crashes was much smaller in the years after the CR year than the reduction in the CR year, the sustainability of the reduction was suggested by the following observations: (1) the linear relationship between the number of years after CRs and crash rates in 2003 (Table 3), (2) the crash ratio in the years before and after CRs (Fig. 1), and (3) the significant adjusted average annual percentage decrease in number of crashes in the years after the CR year. The decrease was obtained after the adjustment for the crash trend in a reference group (Table 5).

There was a linear relationship between the percentage reduction in crashes in the CR year and the year in which the groups received CRs. The 1996 group has the highest percentage decrease 39% and the 2003 group had the least percentage decrease 15%. It is possible that the overall safety performance was better after 2000 than that before 2000, which leaves less room for companies to improve. The percentage of companies who received unsatisfactory rating was greater among the groups that received CRs before 2000 than the groups that received CRs after 2000. CRs were administered by the Federal Highway Administration (FHWA) before 2000 and have been administrated by the FMCSA since 2000. It is also possible that there were differences between FHWA and FMCSA in the way that CRs were conducted and carriers were evaluated.

In conclusion, this study indicates the FMCSA CR program has an instant and long-lasting positive impact on reviewed trucking companies in reducing truck crashes. The positive impact can be observed in reviewed companies of all kinds, large or small, for-hire or private, unsatisfactory or satisfactory in safety rating. However, CRs are resource-intensive and reach only a small percentage of the population of 700,000 active interstate motor carriers every year. Because of that, FMCSA (2007c) is now developing a new operational model, through its comprehensive safety analysis (CSA) 2010 initiative, to assess the motor carrier safety performance of a large segment of the motor carrier industry and to optimize the use of the agency's resources.

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