Final Report 1999-27

Effect of Compliance Reviews on the Out-of-Service Rates of Region 5 Carriers: A Study

433846 335

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC - 1999-27		

4. Title and Subtitle	5. Report Date
EFFECT OF COMPLIANCE REVIEWS ON THE OUT-OF-SERVICE RATES OF REGION 5 CARRIERS: A STUDY	July 1999
	6.

7. Author(s)	8. Performing Organization Report No.
Vikram Khosa Dr. Vladimir Cherkassky	

9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
University of Minnesota Electrical and Computer Engineering 200 Union Street, S.E. Minneapolis, Minnesota 55414	11. Contract (C) or Grant (G) No. (c) 74708 TOC # 21

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155	Final Report 1992-1997
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This Phase II study involved studying the short-term and long-term effects of the Compliance Review (CR) programs conducted in the Region 5 states of Wisconsin, Indiana, Michigan, Minnesota, Ohio, and Illinois on the Out-of-Service (OOS) rates of interstate freight-carriers based in those states.

A preliminary analysis of the inspections data revealed low OSS rates based on inspection records--across all level of inspection--for the years 1993-94, indicating defective collection/interpretation of data and thereby invalidating any OOS rate analysis for this time period. Also, it was found that Level 1 and 2 inspections together constitute nearly 80 percent of all inspections records, thus marginalizing the effect of the other levels of inspection on the final results of this analysis.

The results of both the short-term and long-term effects of OOS rate analysis suggest an overall positive effect of the Compliance Review program on the reduction of OOS (Event and Violation) rates of the carriers. These results are consistent over the rest of the time period (1995-97) and across three levels of inspection (Levels 1, 2, and 3). The conclusions drawn about the nature of the effects of a Compliance Review could be much better validated if the currently spurious inspections data for the years 1993-94 were restored, or a fresh analysis using later available data (1997-99) were carried out based on the same algorithms.

17. Document Analysis/Descriptors	18. Availability Statement
compliance review roadside inspection out of service rates	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	65	

Effect of Compliance Reviews on the Out-Of-Service Rates of Region 5 Carriers: A Study

Final Report

Prepared by

Vikram Khosa
Dr. Vladimir Cherkassky
(Principal Investigator)

Department of Electrical and Computer Engineering,
The University of Minnesota,
200 Union Street SE
Minneapolis MN 55414

July 19, 1999

Published by

Minnesota Department of Transportation
Office of Research Services
First Floor
395 John Ireland Boulevard, MS 330
St. Paul MN 55155

Table of Contents

List Of Tables

List Of Figures

Executive Summary

Phase I of this study, which was completed in 1997, measured the safety performance of Compliance Reviews (CRs) conducted on commercial motor vehicles in Minnesota under the Motor Carrier Safety Assistance Program (MCSAP). The MCSAP program was established in 1982 and is administered by the Federal Highway Administration (FHWA). The Phase I study utilized data collected by the FHWA from two types of MCSAP activities: (1) Compliance Reviews and (2) roadside inspections.

The goal behind the study was to use this historical data to test the hypothesis that Compliance Reviews have a positive impact on motor carrier safety practices in Minnesota, and offer a performance measure of this impact among similar types of carriers. The datasets included Compliance Review records from 1992-94, roadside inspections from 1992-95 and characteristic (size, segment, mileage etc.) data on Minnesota-based carriers.

The response to a Compliance Review is measured using the occurrence of severe violations from roadside inspections - the frequency of Out-Of-Service violations (an Out-Of-Service or OOS violation is a violation of the Federal Motor Carrier Safety Regulations) i.e. the OOS rate. Underlying is the assumption that OOS violations identify imminent dangers to highway safety and a higher accident risk for the associated carrier. The focus of the Phase I study was on the response of a specific segment of the motor carrier industry by comparing the average OOS rate of carriers that had a Compliance Review to that of similar carriers that have not recently had a Compliance Review.

The Phase I study had two major findings: (1) carriers with larger fleets, long-haul operations and hazardous material registration were more likely to be inspected at the roadside, and OOS rates become more accurate (in terms of statistical significance) as a carrier experiences more inspections. (2) a measurable reduction in a carrier's OOS rate occurs in the year after a CR across six out of nine different subpopulations.

The motivation behind this current Phase II of the project was to extend the analyses beyond Minnesota to other Region 5

states, and compare the results to those obtained for Phase I. Also, Phase II would attempt to separate the short-term effects and the longer-term effects of a Compliance Review on a particular segment, based on OOS rates measured across different levels of inspection.

Phase II of this project involved studying the effect of the Compliance Review program conducted in the Region 5 states of Wisconsin, Indiana, Michigan, Minnesota, Ohio and Illinois on the Out-Of-Service (OOS) rates of interstate freight-carriers based in these states. The datasets included Compliance Review records from 1992-96 and inspection data from 1993-97. Separate sub-populations amongst the set of carriers were identified based on a set of distinguishing factors, for the purpose of carrying out meaningful analyses. Hence, carriers were grouped into different sets according to their segment (Private / For-Hire) and their size (Large / Medium / Small).

For each of the above groups of carriers, both the short-term effects as well as the long-term effects of the program were studied in order to identify the temporal characteristics of a carrier's response to a Compliance Review. The short-term effect was measured by comparing the immediate change in the OOS rate for a treatment group (carriers which underwent Compliance Reviews) with respect to the remaining baseline group of carriers (who did not undergo Compliance Reviews). The longer-term effects of the Compliance Reviews were analyzed by comparing the change in the OOS rates for a treatment group and a baseline group in a time period six months after the Compliance Review took place.

Different "levels" of inspections are performed on vehicles and drivers, which vary in the intensity of evaluation and the set of criteria examined. Hence, the above OOS rate analyses were performed for different levels of inspection (Levels 1, 2 and 3) in order to quantify the effect of a Compliance Review on each set of criteria separately.

A preliminary analysis of the inspections data revealed anomalously low OOS rates based on inspections records (across all levels of inspection) for the years 1993-94, indicating defective collection / interpretation of inspections data and thereby invalidating any OOS rate analysis for this time period. Also, it was found that Level 1 and 2 inspections

together constitute nearly 80% of all inspections records, thus marginalising the effect of the other levels of inspection on the final results of our analysis.

The results of the both the short-term effects OOS rate analysis and the longer-term effects OOS rate analysis suggest an overall positive effect of the Compliance Review program on the reduction of OOS (Event and Violation) rates of the carriers. These results are consistent over the rest of the time period (1995-97) and across three levels of inspection (Levels 1,2 and 3). The conclusions drawn about the nature of the effects of a Compliance Review could be much better validated if the currently spurious inspections data for the years 1993-94 were restored, or a fresh analysis using later available data (1997-99) were carried out based on the same algorithms.

1. Pre-Processing and Preliminary Data Analysis

1.1 Introduction and Background

Since 1984, Minnesota, along with other Region 5 states (Wisconsin, Indiana, Michigan, Ohio and Illinois) has participated in the Motor Carrier Safety Assistance Program (MCSAP), a partially federally funded program involved in motor carrier safety initiatives, established in 1982 and administered by the Federal Highway Administration (FHWA). The MCSAP program consists of Safety and Compliance Reviews that are conducted at local motor carrier offices, administration of a federally defined vehicle inspection program, and promotion of motor carrier safety education.

Compliance Reviews are audits conducted on interstate motor carriers to determine their compliance with federal safety regulations, including insurance, driver qualifications, vehicle maintenance and inspection reports, freight bills and accounts, logbooks and vehicle accident records. They are designed to determine if a carrier has the safety management practices in place needed to ensure that the commercial vehicle operations are safe.

Out-Of-Service (OOS) violations, which are identified during a roadside inspection, are severe regulatory violations pertaining to the vehicle and/or driver. It is assumed that a carrier with a high OOS rate (the fraction of vehicle/driver combinations that resulted in OOS violations) carries with it a higher accident risk.

Phase I of this project tested the hypothesis that Compliance Reviews have a positive impact on motor carrier safety practices in Minnesota [1]. The datasets included Compliance Review records from 1992-1994, roadside inspections from 1992-1995 and characteristic data on Minnesota-based motor carriers. Carriers were grouped according to similarity in characteristics such as fleet size, average annual vehicle mileage, average haul distance and the segment to which they belonged - "authorized for-hire", "exempt for-hire" or private.

The study examined frequencies of roadside inspections for different types of carriers and concluded that carriers with larger fleets and more average annual mileage were more likely to be inspected. The major finding was a measurable reduction in Out-Of-Service rates of carriers in Minnesota in

the year after a Compliance Review, observed across six of nine subpopulations.

The purpose of Phase II of this project is to study the effect of the Compliance Review program applied on the carriers based in the Region 5 states, on their OOS rates utilizing the roadside inspections data carried out throughout the nation. The effect of a Compliance Review, if any, is expected not to be confined to inspections within the state in which a given carrier is based - hence, inspection records gathered from other states are also considered.

1.2 Description Of Datasets

Three datasets were directly available for analysis from the FHWA (Federal Highway Administration) database:

1. the **master recordset** file (contains data for segment, size, mileage etc. for each carrier). *(MASTERFL)*

2. the **Compliance Reviews** file (each entry corresponds to a compliance review carried out for a particular carrier during the period 1992 - 1996). *(REVIEWFL)*

3. the **inspection records** file (each entry corresponds to a single inspection carried out for a particular carrier, and also contains the number of OOS violations found, during the period 1993-1997). *(INSPFL)*

See **Appendix A** for the complete description of the above datasets.

1.3 Preprocessing of Database Files

Bad carrier records (e.g. those with missing / invalid important fields such as Total Mileage or Size of Carrier) were eliminated from the **master recordset**. Carriers were grouped according to segment and size. The resulting dataset consisted of a total of 30,600 records.

Records with anomalous values (> 10) for the number of OOS violations, which constitute nearly 1% of the total number of inspections, were

eliminated from the **inspections dataset**. Several records among these had values which ran into hundreds of OOS violations, which is clearly impossible.

Each record in the **compliance reviews** and the **inspections** datasets was tagged with the half-year (6-month period) in which the Compliance Review and inspection was carried out respectively.

See **Appendix B** for the complete set of pre-processing algorithms applied on each of the three datasets.

1.4 Preliminary Data Analysis

A **baseline** group of carriers is identified as those carriers which did not undergo any Compliance Reviews throughout the period 1992 - 96. This constitutes nearly 70% of all the carriers listed in the master recordset.

Two types of OOS rates were defined for each set of inspections carried out during a particular period : the **OOS event rate** (the average number of OOS events per inspection) and the **OOS violation rate** (the actual number of OOS violations per inspection). An OOS event is counted if at least one OOS violation occurs during a particular inspection.

An overall analysis of the OOS rates **in aggregate** and separated **by the level of inspection** was carried out for the baseline group of carriers, in order to observe the breakdown of inspection records according to level of inspection and any irregularities in the OOS rate data that might show up. The level of a particular inspection corresponds to the extent and type of parameters inspected (e.g. Vehicle, Driver).

The results are shown in Section 1.6.

1.5 Grouping Of Carriers

In order to make any meaningful conclusions about the effect of CRs on the OOS rates of carriers, we need to group the available set of carriers according to their physical characteristics and other factors that could have a bearing on the nature of their response to the Compliance Review program. The grouping of carriers reflects a trade-off between the following two objectives :

(1) splitting all carriers into smaller groups of similar carriers,
(2) maintaining a group size large enough to ensure statistical significance of the OOS rates observed in each group.

Hence, the threshold for the average number of inspections per carrier in a particular group of carriers (for a six-month period) is empirically chosen at 7, so that the corresponding OOS rate is statistically significant.

The available set of carriers is grouped according to the following factors:

1. Size : Small (1-2 vehicles), Medium (2-15 vehicles), Large (> 15 vehicles)
2. Segment : Private , For-Hire

The combined resulting types within the complete list of carriers are listed as follows :

Table 1.1 Grouping Of Carriers

Type	Number Of Carriers
PL (Private Large)	1208
PM (Private Medium)	8826
PS (Private Small)	10229
FL (For-Hire Large)	2228
FM (For-Hire Medium)	4612
FS (For-Hire Small)	3397

1.6 Results of Preliminary Data Analysis

The following tables contain the statistics of inspections in aggregate and of levels 1-5 for each six-month period from 1993 (2^{nd} Half) to 1997 (2^{nd} Half) for the **baseline** group of carriers (carriers which did not undergo Compliance Reviews during the above mentioned period) collected from all the states. The six-month period is chosen keeping in view the OOS rate analysis of the inspection records corresponding to the hypotheses developed later, which involve the concept of six-month time windows.

For the table for Level of Inspection x,

(Level x) No. of inspections = the total number of inspections of level x carried out for the baseline group in the half-year corresponding to the row.

(Level x) % of total inspections = the percentage of inspections of level *x* among the total inspections (of all levels) carried out for the half-year corresponding to the row.

(Level x) OOS Event Rate = the average number of OOS events per inspection for the set of inspections of level *x* during the six-month period (corresponding to the row).

(Level x) OOS Violation Rate = the average number of actual OOS violations per inspection for the set of inspections of level *x* during the six-month period (corresponding to the row).

(Level x) Sample Size = the total number of baseline carriers inspected at level *x* during the half-year corresponding to the row.

(Level x) Inspection Rate = the average number of inspections of level *x* carried out per baseline group carrier during the half-year corresponding to the row.

Note: Refer to Section 1.4 for definitions of an OOS Event and an OOS Violation.

1.6.1 Results

Table 1.2 Total Number Of Inspections For The Baseline Group From 1993 (2nd Half) to 1997 (2nd Half)

Half Year	Total Number of Inspections
1993 (2)	12878
1994 (1)	28951
1994 (2)	27292
1995 (1)	34502
1995 (2)	34695
1996 (1)	34678
1996 (2)	33751
1997 (1)	39638
1997 (2)	19079

Symbols :

H1 == 1st Half
H2 == 2nd Half

Table 1.3(a) Baseline OOS Event Rates (for carriers with no CRs during 1992-96) :

Type	93H2	94H1	94H2	95H1	95H2	96H1	96H2	97H1	97H2
PL	.017	.017	.015	.20	.186	.196	.203	.182	.209
PM	.037	.040	.041	.227	.212	.225	.236	.222	.242
PS	.049	.044	.039	.254	.214	.240	.242	.220	.225
FL	.02	.022	.024	.209	.192	.202	.196	.192	.193
FM	.028	.040	.035	.243	.222	.245	.230	.243	.254
FS	.042	.043	.045	.276	.240	.247	.256	.244	.233

Table 1.3(b) Baseline OOS Violations Rates (for carriers with no CRs during 1992 - 96):

Type	93H2	94H1	94H2	95H1	95H2	96H1	96H2	97H1	97H2
PL	.017	.017	.018	.311	.291	.291	.298	.259	.303
PM	.040	.043	.047	.391	.352	.370	.383	.357	.408
PS	.059	.046	.044	.457	.358	.404	.417	.354	.363
FL	.021	.023	.026	.325	.282	.306	.287	.277	.281
FM	.028	.042	.037	.419	.366	.421	.371	.391	.424
FS	.051	.047	.058	.491	.417	.405	.448	.381	.423

Illustrative Example :

From the above tables [Tables 1.3(a) and 1.3(b)], we can observe that the OOS Event Rate (average number of OOS events per inspection) and the OOS Violations Rate (average number of OOS violations per inspection) for the baseline set of carriers belonging to the Private Large (PL) group for the second half of 1995 (95 H2) is 0.186 and 0.291 respectively.

Table 1.4(a) Baseline Group OOS Rates (Level 1 Inspections)

Half Year	No. of inspections	% of total inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1993 (2)	5138	39.9%	.042	.045	2093	2.45
1994 (1)	10823	37.4%	.050	.053	3202	3.38
1994 (2)	11056	40.5%	.051	.058	3211	3.44
1995 (1)	14082	40.8%	.29	.52	3616	3.89
1995 (2)	14458	41.7%	.28	.47	3701	3.91
1996 (1)	12832	37.0%	.31	.55	3535	3.63
1996 (2)	12646	37.5%	.31	.52	3383	3.74
1997 (1)	14555	36.7%	.30	.49	3568	4.08
1997 (2)	7562	39.6%	.30	.52	2454	3.08

Table 1.4(b) Baseline Group OOS Rates (Level 2 Inspections)

Half Year	No. of inspections	% of total inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1993 (2)	5129	39.8%	.021	.023	2025	2.53
1994 (1)	11512	39.8%	.02	.022	3149	3.66
1994 (2)	10184	37.3%	.019	.02	2911	3.50
1995 (1)	13572	39.3%	.20	.30	3636	3.73
1995 (2)	12749	36.7%	.17	.24	3542	3.60
1996 (1)	13840	39.9%	.19	.27	3672	3.77
1996 (2)	13064	38.7%	.19	.25	3403	3.84
1997 (1)	15661	39.5%	.19	.26	3664	4.27
1997 (2)	7063	37.0%	.19	.26	2372	2.98

Table 1.4(c) Baseline Group OOS Rates (Level 3 Inspections)

Half Year	No. of inspections	% of total inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1993 (2)	2126	16.5%	0	0	937	2.27
1994 (1)	4910	17.0%	.0002	.0002	1561	3.15
1994 (2)	4947	18.1%	.0006	.0006	1602	3.09
1995 (1)	6479	18.8%	.10	.11	1788	3.62
1995 (2)	7133	20.56%	.09	.11	2049	3.48
1996 (1)	7423	21.4%	.09	.11	2027	3.66
1996 (2)	7427	22.0%	.09	.10	1995	3.72
1997 (1)	9005	22.7%	.09	.10	2090	4.31
1997 (2)	4217	22.1%	.09	.10	1388	3.04

Table 1.4(d) Baseline Group OOS Rates (Level 4 Inspections)

Half Year	No of inspections	% of total inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1993 (2)	55	0.43%	.018	.018	44	1.25
1994 (1)	149	0.51%	.007	.007	115	1.30
1994 (2)	128	0.47%	.016	.016	108	1.19
1995 (1)	121	0.35%	.14	.27	121	1.17
1995 (2)	208	0.60%	.18	.32	152	1.37
1996 (1)	529	1.52%	.14	.22	351	1.51
1996 (2)	534	1.58%	.20	.28	329	1.62
1997 (1)	344	0.87%	.15	.24	226	1.52
1997 (2)	180	0.94%	.27	.39	134	1.34

Table 1.4(e) Baseline Group OOS Rates (Level 5 Inspections)

Half Year	No. of inspections	% of total inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1993 (2)	430	3.33%	.039	.041	79	5.44
1994 (1)	1557	5.38%	.058	.064	219	7.11
1994 (2)	977	3.58%	.068	.074	142	6.88
1995 (1)	248	0.72%	.33	.63	28	8.86
1995 (2)	147	0.42%	.45	.92	34	4.32
1996 (1)	54	0.16%	.15	.30	16	3.38
1996 (2)	80	0.24%	.21	.44	29	2.76
1997 (1)	73	0.18%	.14	.19	28	2.61
1997 (2)	57	0.3%	.11	.14	7	8.14

Illustrative Example :

From the Table 1.4(a), we can observe that a total of 14458 Level 1 inspections were carried out for a set of 3701 carriers belonging to the baseline group (carriers which did not undergo any Compliance Reviews) during the second half of 1995 (95 H2), which constituted 41.7% of the total number of inspections (Levels 1-5) during the same period. The OOS Event and Violations rates based on Level 1 inspections of this baseline group of carriers during this six-month period are 0.28 and 0.47 respectively.

1.6.2 Observations

1. From the aggregated tables of baseline OOS rates, we observe a *sudden jump* in both the OOS event and violations at the start of 1995 (H1). In other words, extremely low average OOS rates are observed for the period 1993 (H2) - 1994 (H2). This could be attributed to incorrectly collected inspections data for the aforementioned period. This phenomenon of anomalously low OOS event and violation rates is observed for the period 1993 (2^{nd} Half) to 1994 (2^{nd} Half) throughout all levels of inspection. Both the OOS event and violation rates stabilize at the beginning of 1995 to expected levels. Also, there are hardly any (0 - 3) OOS events / violations at Level 3 in the pre-1995 period, reflected in the extremely low OOS Event/Violation rates for that period. This leads us to exclude the faulty inspections data for the pre-1995 period from any further OOS rate analysis.

2. Level 1 and Level 2 comprise *nearly 80% of all inspections* for the baseline group throughout the 9 half-year periods, with each in nearly equal proportions. The percentage of Level 3 inspections continuously increases from 16.5% in 1993 2nd Half to peak at 22.7% in 1997 1st Half. The overall percentage of Level 4 inspections is very low and ranges from 0.4 - 0.6% from 1993 2nd Half to 1995 2nd Half, shows a nearly two-fold increase for 1996 (1.5-1.6%) and then drops to 0.8-0.9% during 1997. Level 5 inspections also form a very low proportion of the total number of inspections. The percentage ranges from 3.5-5.5% during the 1993 2nd Half - 1994 2nd Half period and then drastically reduces to the range 0.2 - 0.7% for the post-1994 period. Level 4 and Level 5 inspections are carried out for a much smaller number (baseline group) of carriers as shown in the above tables as compared to the number of carriers which undergo Level 1 and 2 inspections. Level 3 inspections are also reported for a marginally smaller group of carriers as compared to those for Level 1 and 2. The total number of inspections also shows a significant increase at the beginning of 1995 and a sudden decrease for 1997 2nd Half, as shown in the first table above.

2. Modeling Results and Conclusions

2.1 Modeling Approach

The hypothesis being tested is that a Compliance Review carried out on a group of a given type of carriers has an effect on the Out-Of-Service (OOS) rate, relative to a baseline group.

The main problem is how to quantify this effect, if it indeed exists, in a real-world setting where many other unobserved and possibly dominant factors (weather conditions, policy changes, human behavior etc.) are at play. Based on available empirical evidence, these factors predominantly effect the observed OOS rate itself. However, we can still measure the effect of the Compliance Review program by analyzing *the change in OOS rates* which can be attributed to the effect of Compliance Reviews.

Consider a group of similar carriers for which we observe the Out-Of-Service rates during some time interval before and after a Compliance Review (treatment group). Then, we assume that the following relationship holds for the OOS rates observed for this group:

OOS rate (POST) = OOS rate (PRE) + CR_EFFECT + OTHER_EFFECTS,

Where CR_EFFECT is the effect of the Compliance Review program on the OOS rate,
and OTHER_EFFECTS is the change due to all other (unobservable) factors that affect the OOS rate.

It is assumed that the OTHER_EFFECTS term is a dominant term relative to the CR_EFFECT term in the above relation. Hence, it is not possible to judge the effect of a CR by simply observing the decrease/increase of the OOS rate following a CR.

Now, consider another group of similar carriers none of which underwent any CRs during the above period (baseline group). For this group, the equation looks like :

OOS rate (POST) = OOS rate (PRE) + OTHER_EFFECTS.

For both of the above groups, the OTHER factors are identical, since they belong to the same population and their respective rates are observed during the same time interval. So, we can safely assume that the difference in the OOS rate changes between the baseline and the treatment groups, if any, is mainly due to the CR_EFFECT term. Specifically, if the OOS rate

change in the treatment group is more negative than in the baseline group, we can conclude that the CR program has a positive effect on the reduction of OOS rates.

Further, it is possible to investigate both the short-term and longer-term effects of the CR program by varying the time interval during which the OOS rate is observed. Specifically, by observing the OOS rate changes in a six-month period immediately following the CR event, we can check the hypothesis of the short-term effect of the CR program on the OOS rates. Alternatively, comparing OOS rate changes in a time interval following a certain latency period (say 6 months) after the CR event will test the hypothesis about the longer-term effects of the CR program.

2.2 Short-Term Effect Of A CR

2.2.1 Hypothesis

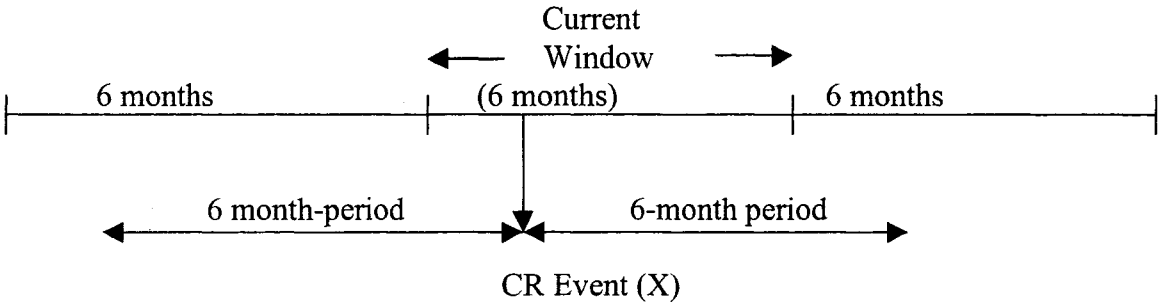
This model is based on the underlying assumption that a Compliance Review starts showing effects on the Out-Of-Service rate of a particular carrier immediately (the next day after the CR is completed).

The hypothesis being tested is that a Compliance Review carried out on a particular type of carrier for a particular period has an effect on the Out-Of-Service (Event and Violation) Rates according to the methodology described in the preceding section.

2.2.2 Methodology

In this approach, the pre- and post-OOS rates for carriers which underwent a CR in a particular six-month period are computed by considering each carrier separately first, pinpointing the exact CR date X within that six-month period and counting the total number of OOS events and violations for inspections carried out within six months before X and after X. These are aggregated to constitute the pre- and post-OOS rates respectively.

The baseline group here is the group of carriers which have never had a CR. Since there are no CR dates around which to calculate the pre- and post-OOS rates, the overall OOS rates for each six-month period *prior to* and *after the* six-month window (in which X lies) are taken as the baseline rates.



2.2.3 Implementation

First the INSPFL database is merged separately with each of the 5 CR datasets each corresponding to a half-year (1995 1st Half to 1997 1st Half). The inspection records in each resulting table are tagged with either of PRE, POST or OUT, depending on whether the inspection was carried out within six months (before - PRE; after -POST) or outside the six-month range on either side (OUT). Next, the records are aggregated (adding the # of OOS events/violations) according to the DOT# and the tag as the break (category) variables.

Then, each of these tables is split according to the PRE/POST tags. Next the PRE and POST tables are merged with the MASTERFL database separately. The merged tables each now contain, for each carrier, the total number of PRE/POST OOS events/violations/inspections for a particular six-month window. These records are now aggregated according to type of carrier, and then the actual OOS rates are computed.

The PRE-CR OOS rate and POST-CR OOS rate for a carrier which underwent a CR in a particular six-month window, from 1995 (2nd Half) - 1996 (2nd Half) are computed as follows:

1. Pinpointing the exact CR date **X** within that six-month window,

2. Counting the total number of OOS events and violations for inspections carried out within **6 months before** X and **after** X,

3. Aggregating the above totals and the total number of inspections over each **type of carrier** to compute the PRE-CR and POST-CR OOS rates respectively as follows:

PRE-CR Event Rate = Total # of PRE-CR OOS Events / Total # of PRE-CR inspections

PRE-CR OOS Rate = Total # of PRE-CR OOS Violations / Total # of PRE-CR inspections

POST-CR Event Rate = Total # of POST-CR OOS Events / Total # of POST-CR inspections

POST-CR OOS Rate = Total # of POST-CR OOS Violations / Total # of POST-CR inspections

The **baseline group** is the group of carriers which have never had a CR during this period. The baseline OOS rates are calculated for the carriers in the baseline group for each six-month period.

The overall OOS event and violation rates for each **6-month window** and for each **type of carrier** prior to and after the six-month window in which X lies are taken as the **baseline OOS event and violation rates** respectively, in order to measure the overall effect.

The change in the OOS rate for the treatment group (difference between the average of the PRE-CR OOS rates and the average of the POST-CR OOS rates as calculated above for a particular six-month window) is compared against the average of the following two quantities :

1. Change in the OOS rate of the baseline group from the earlier six-month period to the current window, and

2. Change in the OOS rate of the baseline group from the current window to the next six-month period.

The latter quantity provides a measure of the overall change in the OOS rates of carriers in the baseline group through the current six-month window, and thus a baseline for comparison against the change in the OOS rates observed for the treatment group during
the same period.

2.2.4 Results

Inspection records from only 1995 (1st Half) onwards were included in the analysis because of the anomalously low OOS rates for the period 1993 (2nd Half) to 1994 (2nd Half), as discovered in the preliminary analysis. Only three types of carriers (FL, FM and PL) showed inspection rates above the empirically-chosen threshold of an average of 7 inspections / carrier, and therefore, the results of the (level) aggregate analysis are displayed only for these types of carriers. In the case of level-based analysis, further segregation according to type of carrier was not done because it would reduce the inspection rates to below an average of 7 inspections per carrier.

PL - Private Large
FL - For-Hire Large
FM - For-Hire Medium

Additional Fields :

Event Variance = Variance of the mean OOS Event rates for all carriers in a group
OOS Variance = Variance of the mean OOS Violation rates for all carriers in a group
Sample Size = Total # of carriers of a particular type included in the group
Inspection Rate = Total # of Inspections / Sample Size

Treatment Group :

Table 2.1(a) OOS Rates For Window 1 (1995 2nd Half)

Type	PRE / POST	Event Rate (Variance)	OOS Rate (Variance)	Inspection Rate	Sample Size
PL	PRE	.29 (.06)	.42 (.17)	6.61	56
	POST	.21 (.06)	.32 (.23)	6.30	50
FL	PRE	.27 (.02)	.45 (.10)	47.58	287
	POST	.23 (.02)	.36 (.07)	43.18	293
FM	PRE	.34 (.07)	.61 (.66)	8.12	246
	POST	.29 (.06)	.47 (.30)	7.04	242

Table 2.1(b) OOS Rates For Window 2 (1996 1st Half)

Type	PRE / POST	Event Rate (Variance)	OOS Rate (Variance)	Inspection Rate	Sample Size
PL	PRE	.18 (.056)	.272 (.35)	12.84	74
	POST	.24 (.056)	.382 (.26)	13.05	79
FL	PRE	.23 (.026)	.373 (.13)	46.92	358
	POST	.252 (.021)	.406 (.10)	51.89	359
FM	PRE	.297 (.05)	.5 (.29)	7.82	258
	POST	.334 (.06)	.585 (.29)	8.1	262

Table 2.1(c) OOS Rates For Window 3 (1996 2nd Half)

Type	PRE / POST	Event Rate (Variance)	OOS Rate (Variance)	Inspection Rate	Sample Size
PL	PRE	.21 (.05)	.34 (.15)	11.29	66
	POST	.21 (.07)	.33 (.22)	10.13	62
FL	PRE	.25 (.02)	.4 (.08)	45.44	344
	POST	.23 (.02)	.35 (.06)	46.38	347
FM	PRE	.30 (.07)	.52 (.30)	7.82	259
	POST	.27 (.05)	.45 (.28)	8.19	255

Illustrative Example:

From the Table 2.1(a), we can observe that the average number of OOS events and violations per inspection during a six-month period prior to a Compliance Review during the second half of 1995 for a set of 56 carriers (with an average of 6.61 inspections per carrier) belonging to the Private Large (PL) group are 0.29 and 0.42, with variances of 0.06 and 0.17 respectively. Similarly, the average number of OOS events and violations per inspection during a six-month period after a Compliance Review during the same period for a set of 50 carriers (with an average of 6.30 inspections per carrier) belonging to the same group are 0.21 and 0.32, with variances of 0.06 and 0.23 respectively.

The above tables show the PRE-CR and POST-CR OOS rates for the above three groups of carriers extending over a period of three consecutive six-month windows. These can be compared against the corresponding baseline rates for the same windows in Tables 1.3 (a) and (b).

Table 2.2 OOS Rates Percentage Change Analysis

Period	Group	% change in OOS Event Rate (PL)	% change in OOS Violation Rate (PL)	% change in OOS Event Rate (FL)	% change in OOS Violation Rate (FL)	% change in OOS in Event Rate (FM)	% change in OOS Violation Rate (FM)
1995 (H1) - 1995 (H2)	Baseline	-7	-6.43	-8.13	-13.23	-8.64	-12.65
1995 (H2) PRE-POST	Treatment	-26.57	-24.88	-15.94	-19.06	-14.28	-22.2
1995 (H2) - 1996 (H1)	Baseline	5.38	0	5.21	8.51	10.36	15.02
1996 (H1) PRE-POST	Treatment	28.8	40.44	7.23	8.85	12.45	17
1996 (H1) - 1996 (H2)	Baseline	3.57	2.75	-2.97	-6.21	-6.12	-11.88
1996 (H2) PRE-POST	Treatment	0.48	-0.89	-8.27	-11.03	-12.38	-13.15
1996 (H2) - 1997 (H1)	Baseline	-10.34	-13.08	-2.04	-3.48	5.65	5.39

The above table shows the percentage change from the average PRE-CR to the POST-CR OOS rates for carriers which underwent Compliance Reviews (treatment group) during a six-month period (Window X). This change is compared against the average of the percentage changes in the OOS rates from the earlier six-month period (Window X-1) and to the next six-month period (Window X+1).

Illustrative Example:

The percentage change in the OOS Event and Violations rates (percentage change in the average number of OOS events and violations per inspections before and after a Compliance Review) observed during the second half of 1995 (H2) for carriers belonging to the Private Large group (which underwent at least one Compliance Review during that period) is -

26.57% and -24.88% respectively. The percentage change in the OOS event and violation rates for the baseline group of carriers from the first half of 1995 (H1) to the second half of 1995 (H2) is -7% and -6.43% while the corresponding percentage change in the OOS event and violation rates for the same group of carriers from the second half of 1995 to the first half of 1996 is 5.38% and 0% respectively, as observed from Tables 1.3(a) and 1.3(b). The measure of the overall percentage change in baseline OOS Event and Violation rates during the second half of 1995 is estimated by the average of the percentage changes for 1995(H1) - 1995(H2) and 1995(H2) - 1996(H1) (-1.19% and -3.21% respectively). Compared to the corresponding changes in the baseline OOS Event and Violation rates (-26.57% and -24.88%), we can conclude that the carriers belonging to the Private Large group which underwent Compliance Reviews during second half of 1995 showed a steeper decline in OOS event and violation rates than carriers which did not (baseline group), thus supporting the hypothesis that the Compliance Review program has a positive influence on the reduction of both OOS Event and Violation rates.

2.2.5 Level-based Analysis Of OOS Rates

The following tables contain the statistics of inspections of levels 1-3, for carriers which underwent CRs in the following half-years : 1995 (2^{nd} Half), 1996 (1^{st} Half) and 1996 (2^{nd} Half). The **PRE** and **POST** OOS event and inspection rates were calculated using inspections carried out on each carrier during the periods within **exactly six months earlier than** and **exactly six months after** each Compliance Review.

Table 2.3(a) Treatment Group OOS Rates (Level 1 Inspections)

Half Year	PRE / POST	No. of inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1995 (2)	PRE	6868	.40	.74	725	9.47
1995 (2)	POST	4976	.38	.69	686	7.25
1996 (1)	PRE	6671	.36	.67	768	8.69
1996 (1)	POST	8212	.38	.72	830	9.89
1996 (2)	PRE	6703	.39	.71	766	8.75
1996 (2)	POST	5748	.39	.70	734	7.83

Table 2.3(b) Treatment Group OOS Rates (Level 2 Inspections)

Half Year	PRE / POST	No. of inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1995 (2)	PRE	6383	.23	.35	708	9.02
1995 (2)	POST	6316	.21	.29	746	8.47
1996 (1)	PRE	8498	.21	.30	826	10.29
1996 (1)	POST	8854	.22	.31	833	10.63
1996 (2)	PRE	7357	.22	.30	790	9.31
1996 (2)	POST	8300	.21	.29	779	10.65

Table 2.3(c) Treatment Group OOS Rates (Level 3 Inspections)

Half Year	PRE / POST	No. of inspections	OOS Event Rate	OOS Violation Rate	Sample Size	Inspection Rate
1995 (2)	PRE	3881	.16	.18	525	7.39
1995 (2)	POST	4503	.12	.14	552	8.16
1996 (1)	PRE	5613	.14	.16	639	8.78
1996 (1)	POST	5899	.13	.15	647	9.12
1996 (2)	PRE	4962	.14	.16	630	7.88
1996 (2)	POST	5870	.13	.15	625	9.39

The following tables show a level-wise percentage change analysis of Baseline and Treatment Group OOS event and violation rates through the half-years 1995 (2^{nd} Half) to 1996 (2^{nd} Half). Consecutive entries belong to :

1. Change in OOS Event and Violation rates in the **baseline** group (carriers which did not undergo any CRs) from half-year X-1 to X.

2. Changes from the PRE- OOS Event and Violation Rates to POST- OOS Event and Violation Rates in the **treatment** group (carriers which underwent CRs) for the half-year X.

3. Change in OOS Event and Violation rates in the **baseline** group (carriers which did not undergo any CRs) from half-year X to X+1.

For each level, the effect of CRs on the OOS Event and Violation rates for a particular half-year X can be observed by comparing the percentage change in entry 2 against the average of the percentage changes in entries 1 and 3. If the former quantity is more negative than the latter (which provides a measure of the overall change in baseline OOS rates during that period), it supports our hypothesis and vice versa.

Table 2.4(a) Level 1 OOS Rates Percentage Change Analysis

Period	Group	% change in OOS Event Rate	% change in OOS Violation Rate
1995 (1) - 1995 (2)	Baseline	-3.45%	-9.61%
1995 (2)	Treatment	-5.0 %	-6.75 %
PRE - POST			
1995 (2) - 1996 (1)	Baseline	10.71%	17.02%
1996 (1)	Treatment	5.26%	7.46%
PRE - POST			
1996 (1) - 1996 (2)	Baseline	0%	-5.45%
1996 (2)	Treatment	0%	-1.4%
PRE - POST			
1996 (2) - 1997 (1)	Baseline	-3.22%	-5.77%

Table 2.4(b) Level 2 OOS Rates Percentage Change Analysis

Period	Group	% change in OOS Event Rate	% change in OOS Violation Rate
1995 (1) - 1995 (2)	Baseline	-15%	-20%
1995 (2)	Treatment	-8.7%	-6.75%
PRE-POST			
1995 (2) - 1996 (1)	Baseline	11.76%	12.5%
1996 (1)	Treatment	5.26%	7.46%
PRE-POST			
1996 (1) - 1996 (2)	Baseline	0%	-7.07%
1996 (2)	Treatment	0%	-1.4%
PRE-POST			
1996 (2) - 1997 (1)	Baseline	0%	4.0%

Table 2.4(c) Level 3 OOS Rates Percentage Change Analysis

Period	Group	% change in OOS Event Rate	% change in OOS Violation rate
1995 (1) - 1995 (2)	Baseline	-10%	0%
1995 (2)	Treatment	-25%	-22.22%
PRE-POST			
1995 (2) - 1996 (1)	Baseline	0%	0%
1996 (1)	Treatment	-7.14%	-6.25%
PRE-POST			
1996 (1) - 1996 (2)	Baseline	0%	-9.09%
1996 (2)	Treatment	-7.14%	-6.25%
PRE-POST			
1996 (2) - 1997 (1)	Baseline	0%	0%

Illustrative Example :

The percentage change in the Level 1 OOS Event and Violations rates (percentage change in the average number of OOS events and violations per inspections before and after a Compliance Review) observed during the second half of 1995 (H2) for all types of carriers (which underwent at least one Compliance Review during that period) is -5.0% and -6.75% respectively. The percentage change in the OOS event and violation rates for the baseline group of carriers from the first half of 1995 (H1) to the second half of 1995 (H2) is -3.45% and -9.61% while the corresponding percentage change in the OOS event and violation rates for the same group of carriers from the second half of 1995 to the first half of 1996 is +10.71% and +17.02% respectively. The measure of the overall percentage change in baseline Level 1 OOS Event and Violation rates during the second half of 1995 is estimated by the average of the percentage changes for 1995(H1) - 1995(H2) and 1995(H2) - 1996(H1) (+3.63% and +3.70% respectively). Compared to the corresponding changes in the baseline OOS Event and Violation rates (--3.45% and -6.75%), we can conclude that the carriers belonging to the Private Large group which underwent Compliance Reviews during second half of 1995 showed a steeper decline in Level 1 OOS event and violation rates than carriers which did not (baseline group).

2.2.6 Discussion Of Results

1. The percentage change (from PRE to POST) in both OOS Event and Violation rates for CRed carriers for a particular half-year X is almost always consistently lower than the average of the following percentage changes in the baseline rates, which provide a reasonable measure of the overall change in OOS rate for the baseline group during the same period:

i. from the previous half-year (X-1) to the current half-year (X)
ii. and from the current half-year (X) to the next half-year (X-1).

For example, consider the second half of 1995 - the PRE-POST percentage decrease of the OOS Event rate for Level (1,2,3) inspections is (-5%,-8.7%,-25%) which is greater than the average of the percentage changes in the baseline OOS event rate from 1995(1^{st} Half) - 1995(2^{nd} Half) and 1995(2^{nd} Half) - 1996(1^{st} Half) (-3.73%, -1.62%,-5%). A similar analysis of the OOS Violations rate for Levels 1,2,3 leads to the same conclusion.

The results of the OOS Event Rate analysis are graphically displayed in Figures 1(a), 2(a) and 3(a), and the results of the OOS Violation Rate analysis are shown in Figures 1(b), 2(b) and 3(b).

2. This is also observed throughout all three levels of inspection. It is especially seen clearly in the case of Level 3 inspections (where there is zero change in the baseline rate for the year 1996) - in this case, all the PRE-OOS to POST-OOS event and violation changes are negative.

3. The only exception observed in the table of aggregated OOS rates is the period 1996 (1^{st} Half), which shows a positive change for the treatment group vs. the changes of the baseline OOS rates for 1995(2^{nd} Half) to 1996(1^{st} Half) and 1996 (1^{st} Half) to 1996 (2^{nd} Half). This could be explained by the high variance in the OOS violation rate during this period (indicating that some inspections have much higher than average OOS rates), especially in the case of Private Large (PL) carriers.

4. An exception for the Level-wise analysis results is seen only for Level 1 inspections, where the PRE - POST OOS violation rate percentage change (-1.4%) is less negative than both the percentage changes in baseline OOS violation rates from 1996 (1^{st} Half) - 1996 (2^{nd} Half) (-5.45%) and from 1996 (2^{nd} Half) - 1997 (1^{st} Half) (-5.77%).

5. The PRE- and POST- OOS event and violation rates (for the carriers which underwent CRs) are , on an average, higher than the corresponding rates for the baseline group. This indicates that carriers with high OOS event and violation rates might have been targeted for Compliance Reviews.

Keeping the above results in view, we can reasonably conclude that the CR program has an overall negative short-term effect on both the OOS Event and Violation rates for carriers across all levels of inspection.

Figure 1(a) : Level 1 OOS Event Rate Analysis (Short-term Effect)

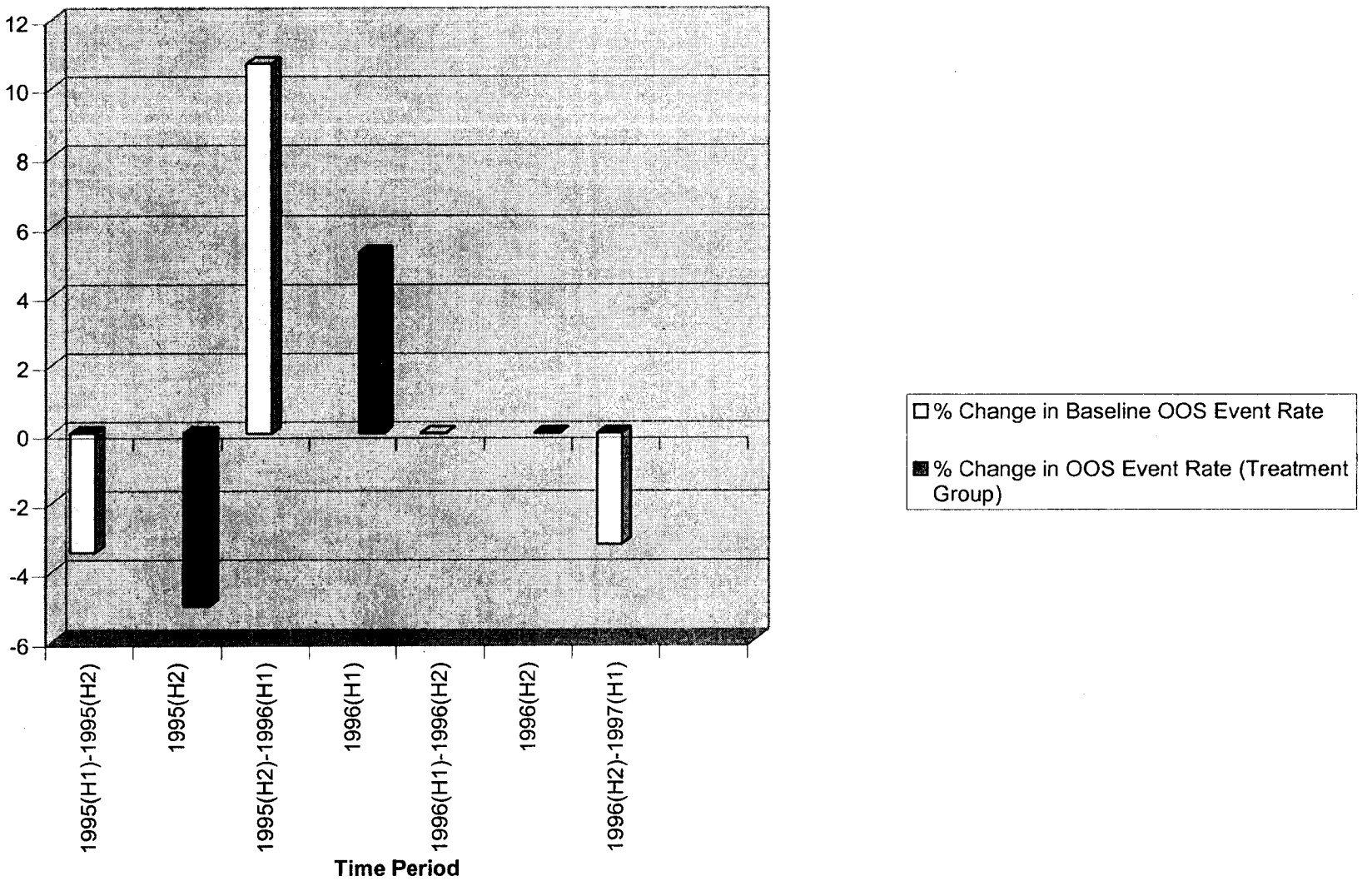


Figure 1(b): Level 1 OOS Violation Rate Analysis (Short-term Effect)

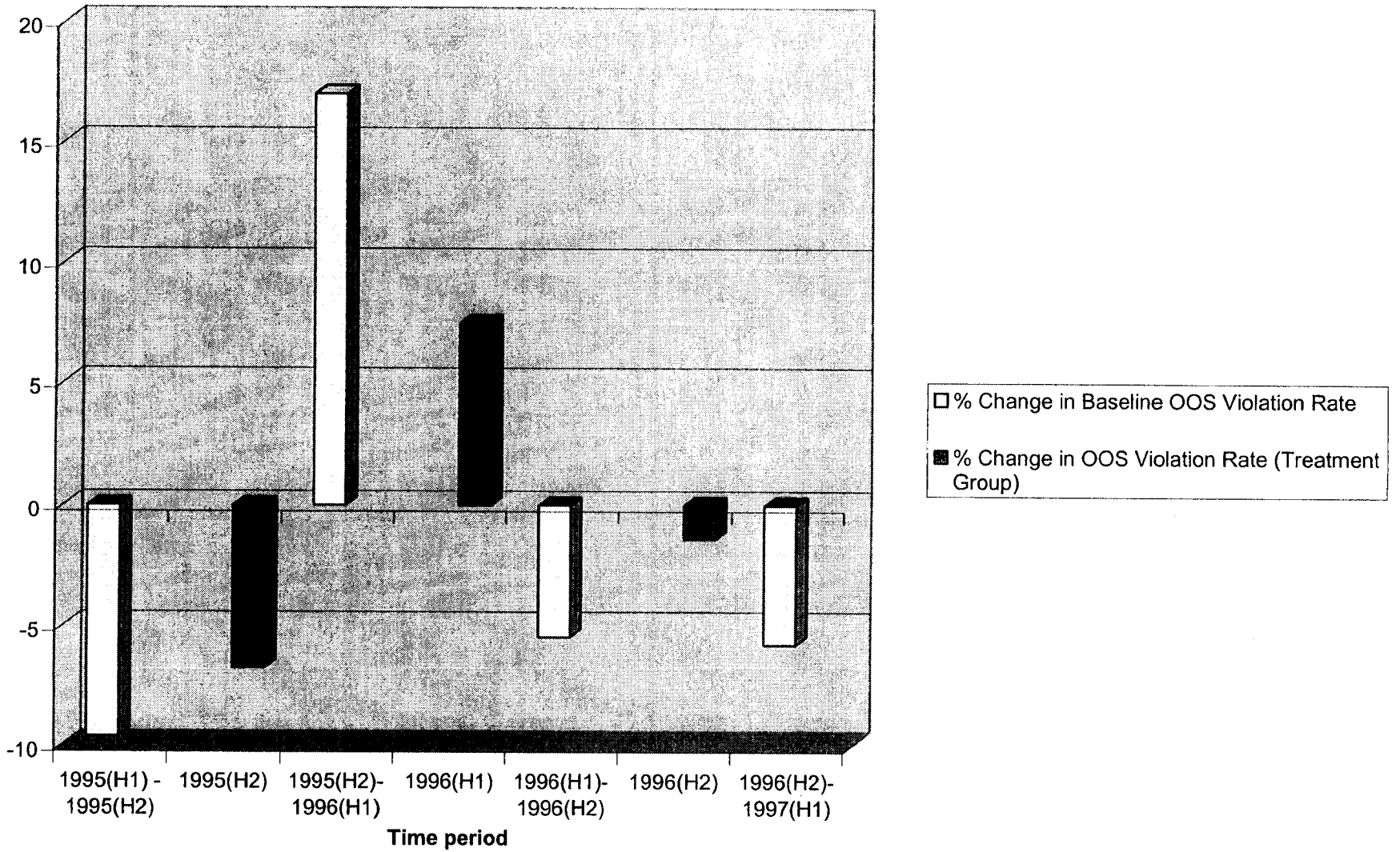


Figure 2(a): Level 2 OOS Event Rate Analysis (Short-Term Effect)

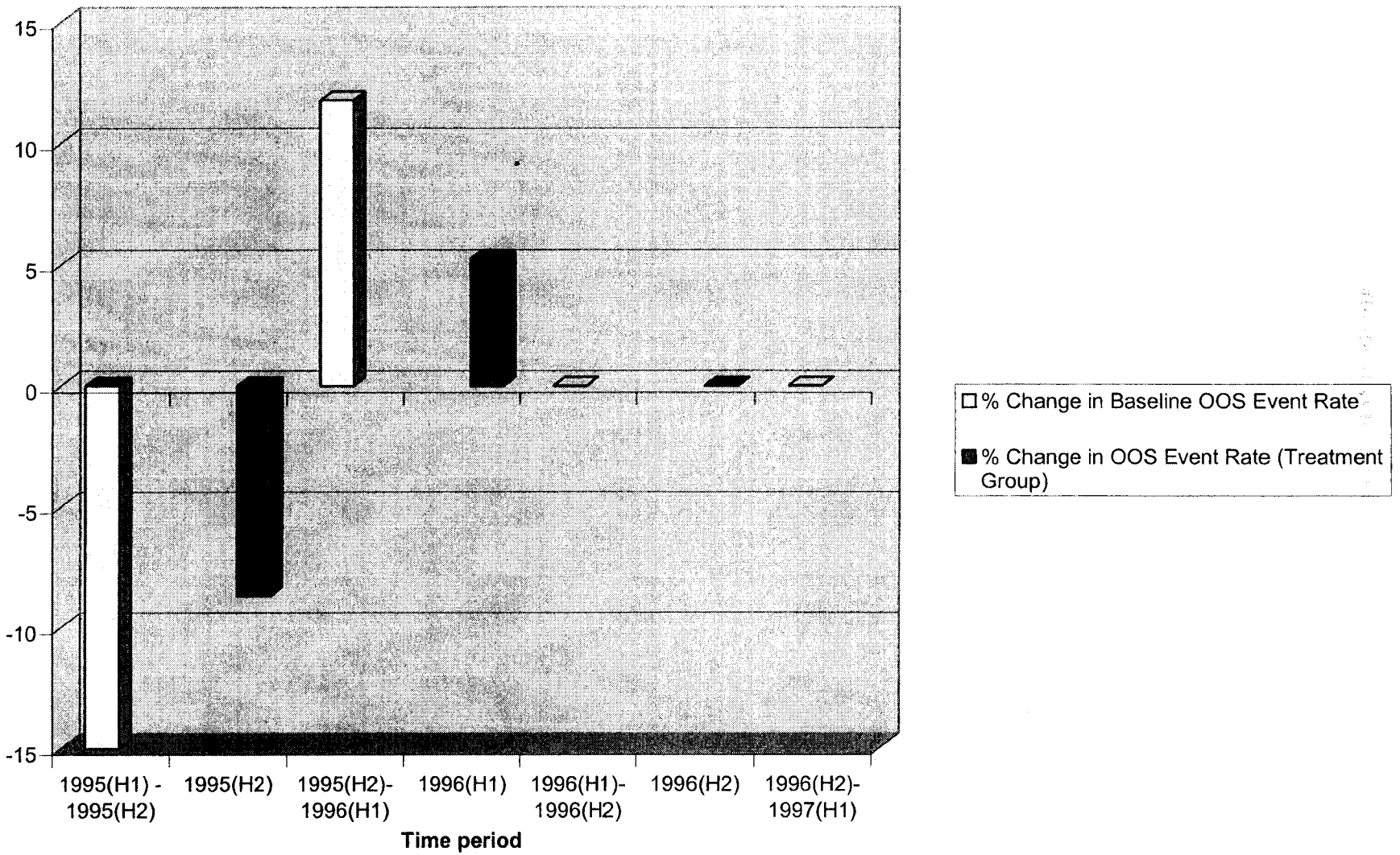


Figure 2(b): Level 2 OOS Violation Rate Analysis (Short-term Effect)

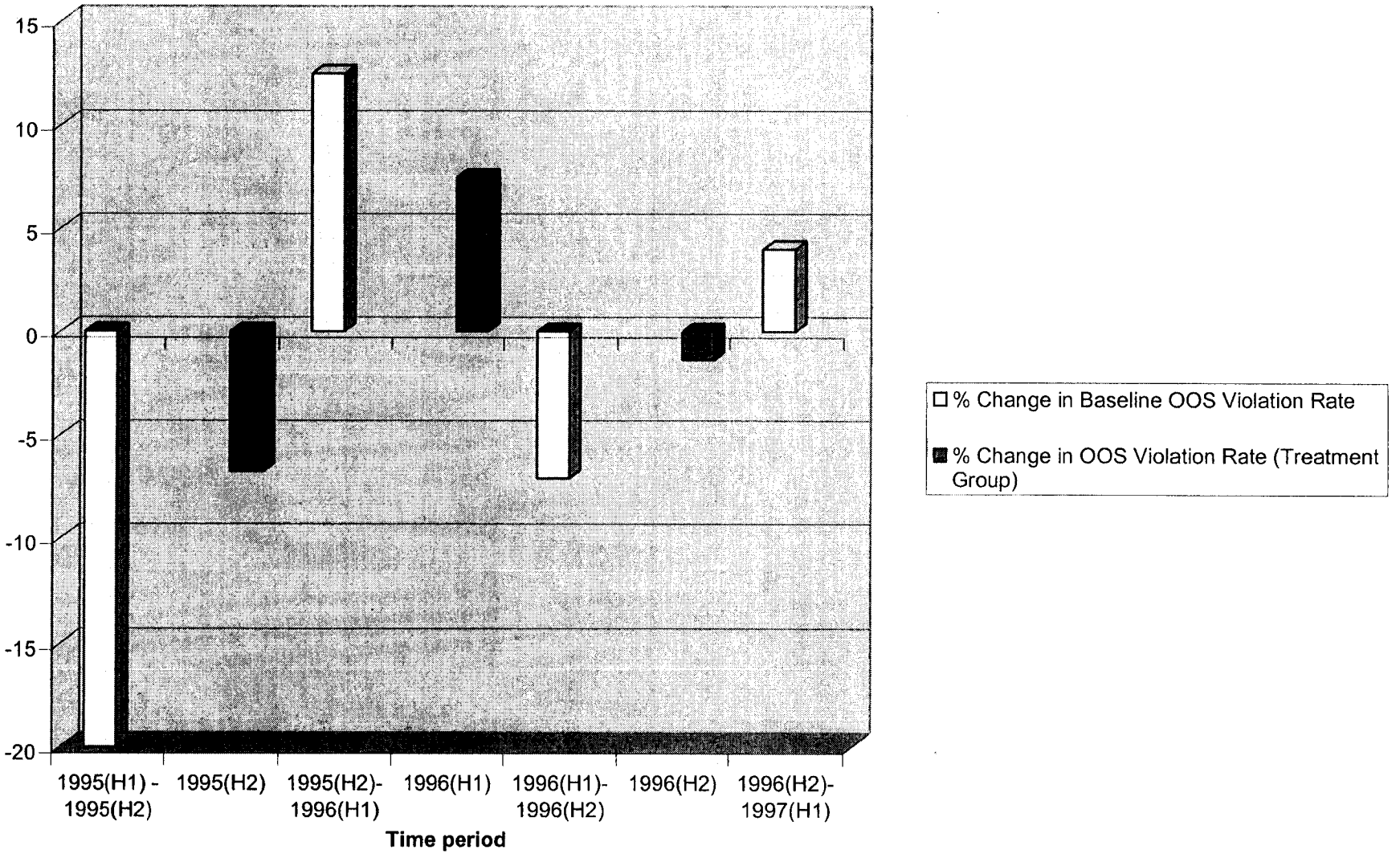


Figure 3(a) : Level 3 OOS Event Rate Analysis (Short-term Effect)

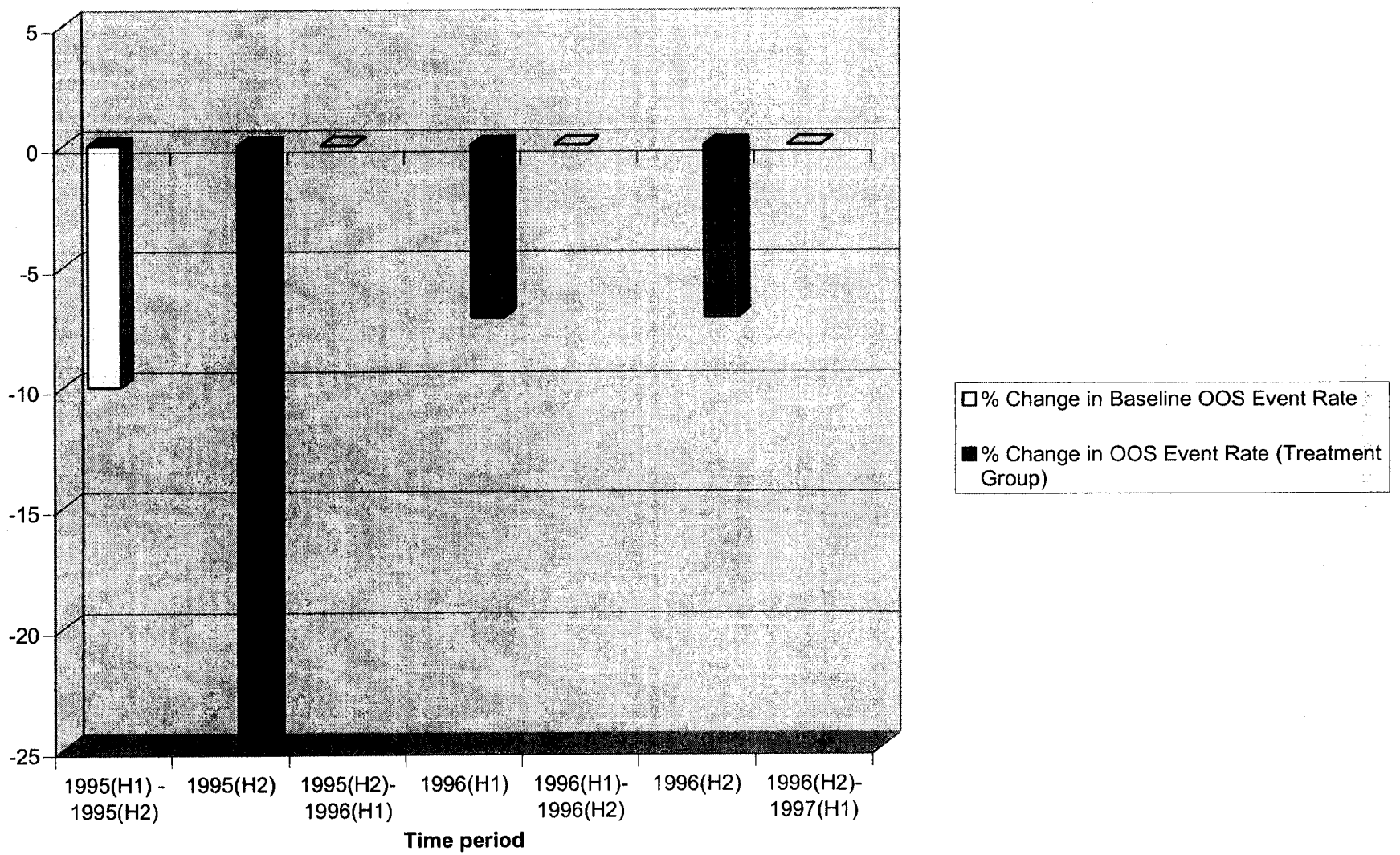
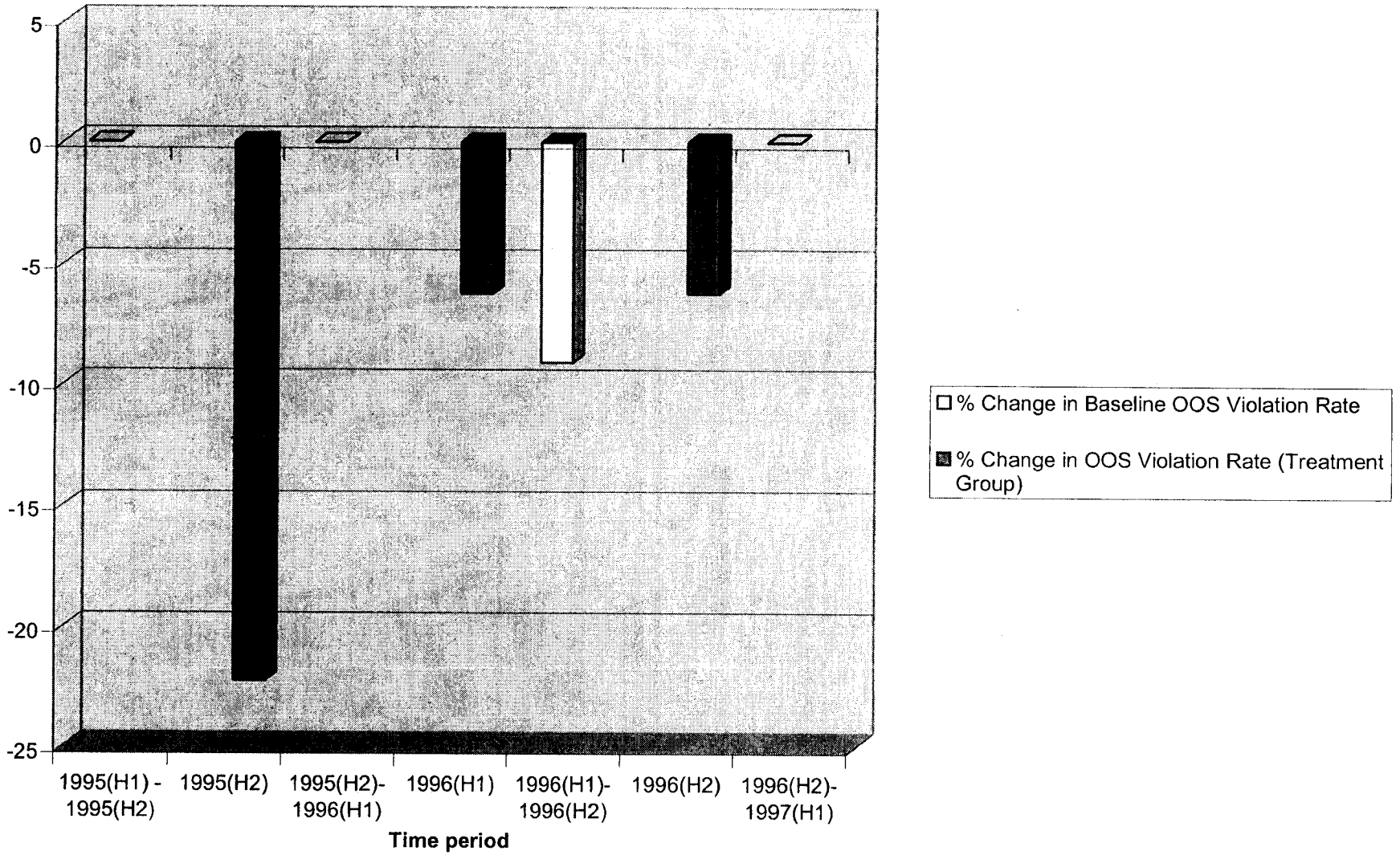


Figure 3(b): Level 3 OOS Violation Rate Analysis (Short-term Effect)



2.3 Long-Term Effect Of A CR

2.3.1 Hypothesis

This modeling approach investigates the effect of a Compliance Review on the OOS rates of a particular carrier after a certain minimum latency period.

The hypothesis being tested is that a Compliance Review carried out on a particular type of carrier for a particular period has a negative effect on the OOS (Event and Violation) Rates according to the methodology described in Section 2.1.

Definitions:

OOS Event Rate: The average number of OOS Events per inspection for a given set of carriers during a specified six-month period.

OOS Violations Rate: The average number of OOS Violations per inspection for a given set of carriers during a specified six-month period.

(*Also* See definitions on Page 11).

Window: A set of consecutive six-month periods for a particular set of carriers where:

- No Compliance Reviews are done during this period for this set of carriers and the inspections records for the same set of carriers during the first 6-month period are used to calculate the pre-CR OOS (event and violations) rates,

- The Compliance Reviews for the same set of carriers are done in the second 6-month period, and

- No Compliance Reviews are done during this period for this set of carriers and the inspections records for a particular set of carriers during the third 6-month period are used to calculate the post-CR OOS (event and violations) rates.

Treatment Group: The particular set of carriers, which do not undergo Compliance Reviews in the first and third six-month periods and undergo Compliance Reviews during the second six-month period corresponding to a particular window .

Baseline Group: The particular set of carriers corresponding to a particular window which do not undergo any Compliance Reviews during any of the three six-month periods defining the window.

2.3.2 Methodology

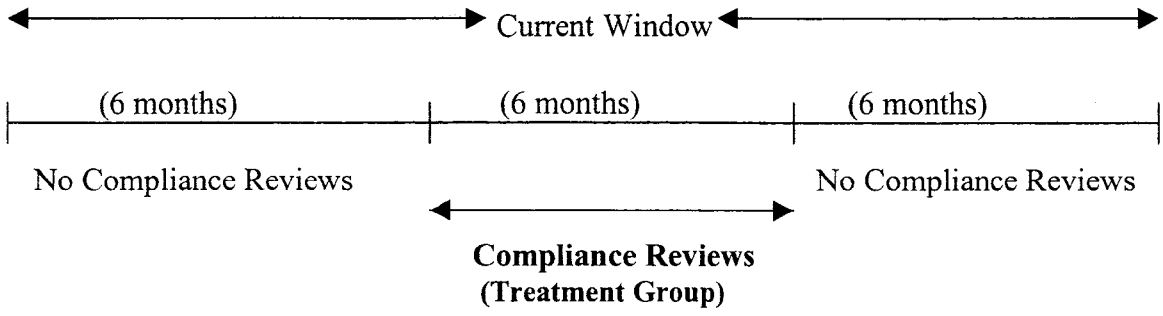
1. According to our hypothesis, the long-term effect of a CR is *assumed* to be visible during the six-month period following the half-year period in which the CR was carried out, i.e. if the CR was done in 2nd half of 1995, the inspection records for 1st half 1996 are now considered as representing the period of long-term effect for that particular CR. The latency period is just the sub-6 month period after the CR until the start of the next six-month period. The reason for selecting the six-month latency period for measuring the long-term effects of a CR stems from *a)* the paucity of carriers which undergo a CR during a particular year and do not undergo a CR during the preceding and succeeding years, thus ruling out a latency period of one year or more and *b)* the small sample sizes and inspection rates lower than the empirically chosen threshold of average 7 inspections per carrier obtained for analysis carried out with the latency period chosen at less than six months.

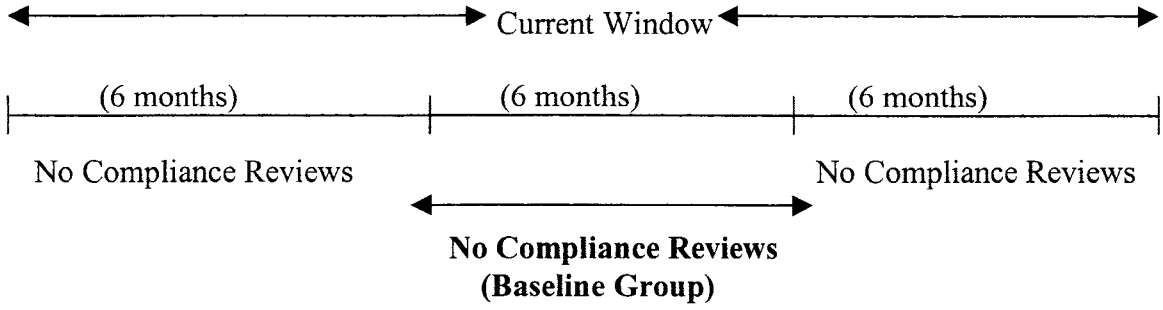
2. The pre-CR OOS rate is the OOS rate for the half-year immediately before the one in which the CR was carried out, e.g. in the above example, the pre-CR OOS rate will be based on inspections done in 1st half of 1995. The post-CR OOS rate is the OOS rate for the half-year immediately after the one in which the CR was carried out. e.g. in the above example, the post-CR OOS rate will be based on inspections done in 1st half of 1996. The effect of the CR program on a set of carriers can be observed by comparing the pre-OOS rates and post-OOS rates.

3. The logical years 1-5 are split into the following 6 time-windows as follows:

Table 2.5 Division into six-month time windows

Window	Pre-Treatment period (to calculate pre-CR OOS rates)	Treatment period	Post-Treatment period (to calculate post-CR OOS rates)
1	1993 (1st half)	1993 (2nd half)	1994 (1st half)
2	1993 (2nd half)	1994 (1st half)	1994 (2nd half)
3	1994 (1st half)	1994 (2nd half)	1995 (1st half)
4	1994(2nd half)	1995 (1st half)	1995 (2nd half)
5	1995 (1st half)	1995 (2nd half)	1996 (1st half)
6	1995 (2nd half)	1996 (1st half)	1996 (2nd half)





If a carrier A belongs to *treatment group* during a window corresponding to a particular **treatment period x**, then the OOS rates for the inspections done in periods **x-1** and **x+1** constitute the **pre-CR** and **post-CR** OOS rates.

The *baseline group* is used as a baseline for comparing the effects of a CR on the OOS rate for a particular type of carrier.

However, since we observed anomalous OOS rates, probably due to bad inspection records, for the periods 1993 (2^{nd} Half) to 1994 (2^{nd} Half), we must exclude windows which contain inspection records from the above mentioned periods (Windows 1 - 4). Thus, results are presented only for Windows 5 and 6.

The above model is replicated for each level of inspection i.e. separate models are constructed for the effects of CRs on OOS Event and Violation rates for different levels of inspection.

Finally, the PRE - POST change in OOS Event and Violations rates for the treatment group is compared against the PRE - POST change in rates for the Baseline group for the same window and level of inspection in order to observe the effect of a CR based on this model.

2.3.3 Implementation

The REVIEWFL database is split into 4 tables each corresponding to each of the half-years considered above (belonging to Windows 5 and 6).
The MASTERFL database is next merged (indexed by US DOT#) with the first of the above 4 tables. Records with valid CR fields were tagged as T (Treatment) and the rest as C (Control). Next, for each level of inspection, the resultant table was merged with the inspection records for the same half-year in the INSPFL database (indexed by USDOT# and half-year).

The above set of operations is carried out cumulatively through the whole set of 4 successive half-year tables. Each carrier record contains the Control/Treatment (C/T) status for a half-year XY (X indicates Year and Y indicates half) , total # of OOS events (not shown above), OOS violations and total # of inspections for each half-year.

Now, status fields W1 and W2 are computed, corresponding to the earlier described set of 2 windows used to determine the pre- and post-CR OOS rates, for each carrier records. i.e. H3 is "Y" for a carrier A means that A belonged to the control group for 1995 (1^{st} Half) and belonged to the treatment group for 1995 (2^{nd} Half).

Finally, the records for each window (W1 and W2) are aggregated in order to compute the pre- and post-CR OOS rates.

Aggregation was also carried out additionally across types of carriers.

2.3.4 Results

The following tables display the PRE- and POST- OOS Event and Violation rates obtained for the treatment and baseline groups for inspections carried out on all carriers at **Levels 1, 2 and 3.** The OOS rates for the treatment group during a window are compared against the OOS rates for the baseline group during the same window.

Levels 4 and 5 inspections were not analyzed due to exceedingly small sample sizes and inspection rates (insufficient statistical significance).

The **window** here corresponds to carriers which underwent a CR in the shown six-month period and did not undergo any CRs in both the earlier and the subsequent six-month periods, for the **treatment group**.

The **baseline group** consists of carriers which did not undergo any CR during the period 1995 (1st Half) to 1996 (2nd Half).

Sample Size is the total number of baseline carriers inspected during the half-year corresponding to the window period.

Inspection Rate = the average number of inspections carried out per baseline group carrier during the half-year corresponding to the window period.

Table 2.6(a1) Level 1 Treatment Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.41	.78	2.46	1358
	POST	.39 (-4.8%)	.77 (-1.28%)	2.31	
1996 (1)	PRE	.35	.64	4.01	1278
	POST	.34 (-2.85%)	.62 (-3.12%)	3.69	

Table 2.6(a2) Level 1 Baseline Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.31	.54	1.17	25293
	POST	.31 (0%)	.55 (1.85%)	1.04	
1996 (1)	PRE	.29	.49	1.19	25293
	POST	.31 (6.45%)	.54 (10.2%)	1.03	

Table 2.6(b1) Level 2 Treatment Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.24	.38	2.55	1358
	POST	.20 (-16.67%)	.27 (-29%)	2.77	
1996 (1)	PRE	.22	.30	3.75	1278
	POST	.21 (-4.54%)	.28 (-6.67%)	4.14	

Table 2.6(b2) Level 2 Baseline Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.20	.30	1.10	25293
	POST	.20 (0%)	.27 (-10%)	1.12	
1996 (1)	PRE	.18	.26	1.03	25293
	POST	.20 (11.11%)	.27 (3.85%)	1.06	

Table 2.6(c1) Level 3 Treatment Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.17	.18	1.38	1358
	POST	.11 (-35.3%)	.13 (-27.78%)	1.71	
1996 (1)	PRE	.14	.16	2.32	1278
	POST	.13 (-7.14%)	.15 (-6.25%)	2.84	

Table 2.6(c2) Level 3 Baseline Group OOS Rates Analysis

Window	PRE/POST	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	.11	.13	.56	25293
	POST	.11 (0%)	.12 (-7.7%)	.65	
1996 (1)	PRE	.11	.12	.61	25293
	POST	.11 (0%)	.12 (0%)	.64	

The following tables display the PRE- and POST- OOS Event and Violation rates of **For-Hire Large** (FL) carriers obtained for the treatment and baseline groups for inspections carried out at **Levels 1, 2 and 3.** The FL group is the only one, among all the groups, which shows an inspection rate above the empirically-chosen threshold of average of 7 inspections per carrier.

The **window** here corresponds to carriers which underwent a CR in the current six-month period and did not undergo any CRs in both the earlier and the subsequent six-month periods, for the **treatment group.**

The **baseline group** consists of carriers which did not undergo any CR during the period 1995 (1st Half) to 1996 (2nd Half).

The figures in *parentheses* for POST OOS Event and Violations Rates indicates the **percentage change** in the corresponding OOS Rate from PRE to POST for that particular group (Treatment / Baseline) , window, type of carrier and level of inspection.

Illustrative Example :

From Tables 2.6(a1) and (a2), we observe that for carriers which underwent a CR during the second half of 1995 (and no CRs during the preceding and suceeding six-month periods), the percentage change in OOS Event and Violation rates measured in the 1st half of 1995 to that measured in the 1st half of 1996 is -4.8% and -1.28% respectively. Compared to this, the corresponding percentage change in OOS Event and Violation rates for the carriers belonging to the baseline group is 0% and 1.85% respectively. Clearly, this indicates a positive effect of CRs on a decrease in both types of OOS rates. This effect is visible for both windows across all three levels of inspection (1,2,3).

Table 2.7(a1) For-Hire Large (FL) Level 1 Treatment Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.40	.75	14.95	180
	POST		.39 (-2.5%)	.75 (0%)	13.19	
1996 (1)	PRE	FL	.35	.65	15.91	240
	POST		.34 (-2.85%)	.62 (-4.6%)	15.24	

Table 2.7(a2) For-Hire Large (FL) Level 1 Baseline Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.30	.51	14.95	1241
	POST		.31 (+3.33%)	.52 (+1.96%)	12.47	
1996 (1)	PRE	FL	.28	.45	14.94	1241
	POST		.30 (+7.14%)	.50 (11.11%)	12.79	

Table 2.7(b1) For-Hire Large (FL) Level 2 Treatment Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.23	.37	14.81	180
	POST		.23 (0%)	.32 (-13.5%)	16.04	
1996 (1)	PRE	FL	.21	.29	16.02	240
	POST		.21 (0 %)	.28 (-3.45%)	17.94	

Table 2.7(b2) For-Hire Large (FL) Level 2 Baseline Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.20	.28	13.61	1241
	POST		.19 (-5%)	.27 (-3.57%)	13.96	
1996 (1)	PRE	FL	.18	.25	12.87	1241
	POST		.20 (+11.11%)	.26 (+4%)	13.73	

Table 2.7(c1) For-Hire Large (FL) Level 3 Treatment Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.16	.17	8.54	180
	POST		.12 (-25%)	.13 (-23.53%)	10.54	
1996 (1)	PRE	FL	.13	.15	10.25	240
	POST		.13 (0 %)	.15 (0 %)	12.78	

Table 2.7(c2) For-Hire Large (FL) Level 3 Baseline Group OOS Rates

Window	PRE/POST	Type Of Carrier	OOS Event Rate (% change)	OOS Violation Rate (% change)	Inspection Rate	Sample Size
1995 (2)	PRE	FL	.11	.13	8.23	1241
	POST		.12 (+9.09%)	.13 (0 %)	9.21	
1996 (1)	PRE	FL	.11	.12	8.72	1241
	POST		.12 (+9.09%)	.13 (+8.33%)	9.21	

The above tables 2.7 (a1)-(c2) should be interpreted in the same way as Tables 2.6 (a1)-(c2).

2.3.5 Discussion Of Results

1. The inspection rates for the aggregated results for all types of carriers are quite low (in the range of 1 - 4). Hence, the results shown above in Tables 2.6(a1)-(c2) are based on inspection rates well below the empirically chosen threshold of average 7 inspections/carrier, and thus, are not robust enough to enable us to draw any firm conclusions.

2. Segregating the results by type of carrier, the inspection rates for all types of carriers except FL (For-Hire Large) for both treatment and baseline groups are lower than the threshold required for the corresponding OOS rate to stabilize (chosen at around 7 inspections / carrier). Therefore, only results for For-Hire Large (FL) type of carriers are shown above, and used for any further inferences for our model.

3. For the For-Hire Large (FL) group of carriers, the percentage change in OOS rates from the PRE-CR period to the POST-CR period for the treatment group of carriers is observed to be consistently more negative than the percentage change in OOS rates between the same period for the baseline group of carriers, with the exception of the records for Level 2 inspections in Window 1 (1995 2^{nd} Half), where the results are otherwise. Moreover, in this case, the inspection rates are high enough to warrant a firm conclusion based on the analysis.

   For example, for the window corresponding to the first half of 1996, the OOS event rate for the treatment group changes by -2.85%, 0%, 0% for Level 1,2,3 inspections respectively. For the same window, the change in the OOS Event rate for the baseline group changes increases by 7.14%, 11.11% and 9.09% for Level 1,2,3 inspections respectively, which clearly shows the positive long-term effect of Compliance Reviews on the decline in OOS event rates. An identical analysis of the OOS Violation rates shows similar results.

   The results of the Level 1,2 and 3 OOS Event and Violations Rate analysis are graphically displayed in Figures 4(a,b) , 5(a,b) and 6(a,b) respectively.

Keeping the above results in view, we can say fairly conclusively that the CR program has a negative long-term effect (with a latency period of up to 6 months) on both the OOS Event and Violation rates for the For-Hire Large (FL) group of carriers across all three levels of inspection (Levels 1,2,3).

Figure 4(a) : Level 1 OOS Event Rate Analysis (Long-Term Effects)

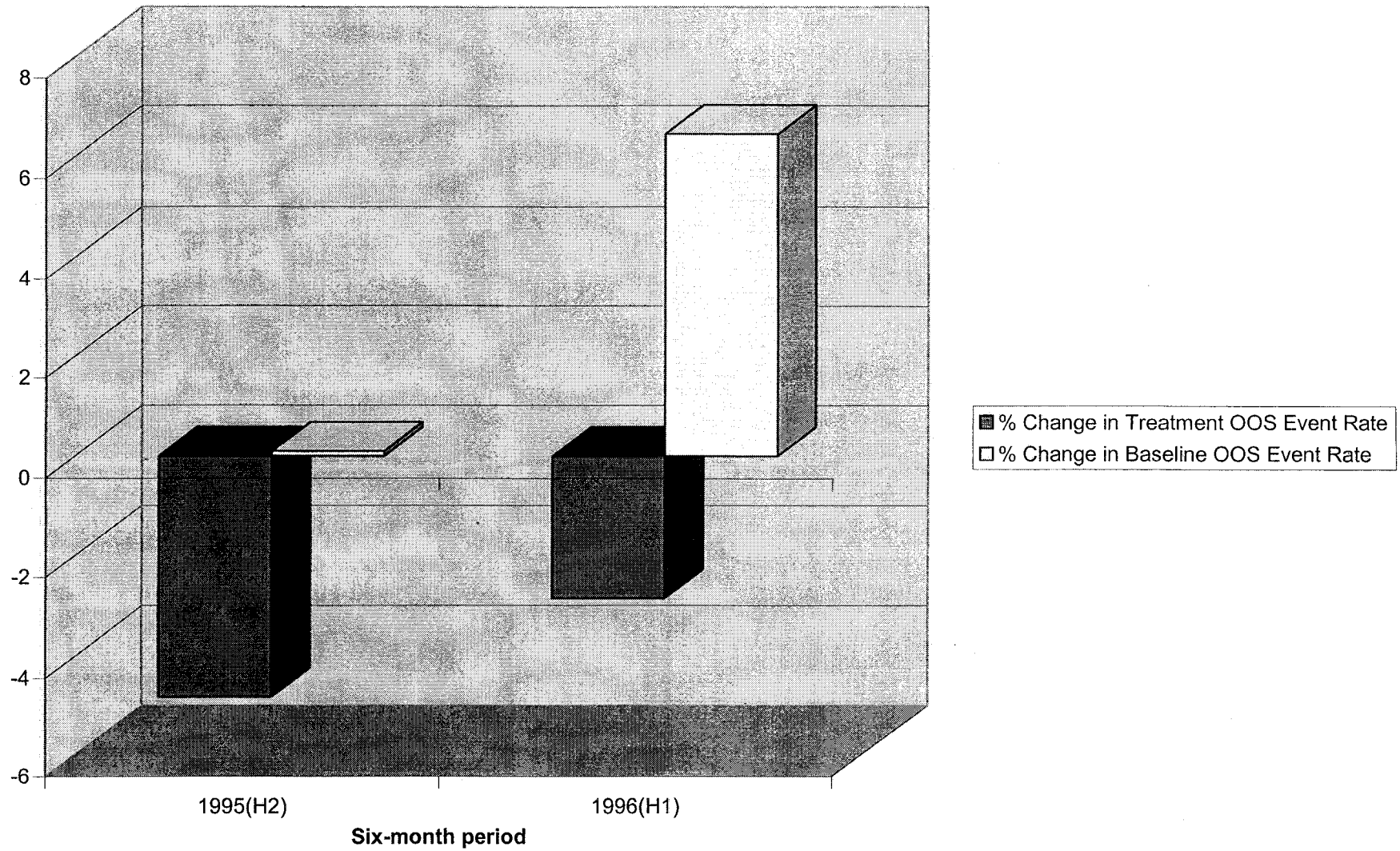


Figure 4(b): Level 1 OOS Violation Rate Analysis (Long-Term Effect)

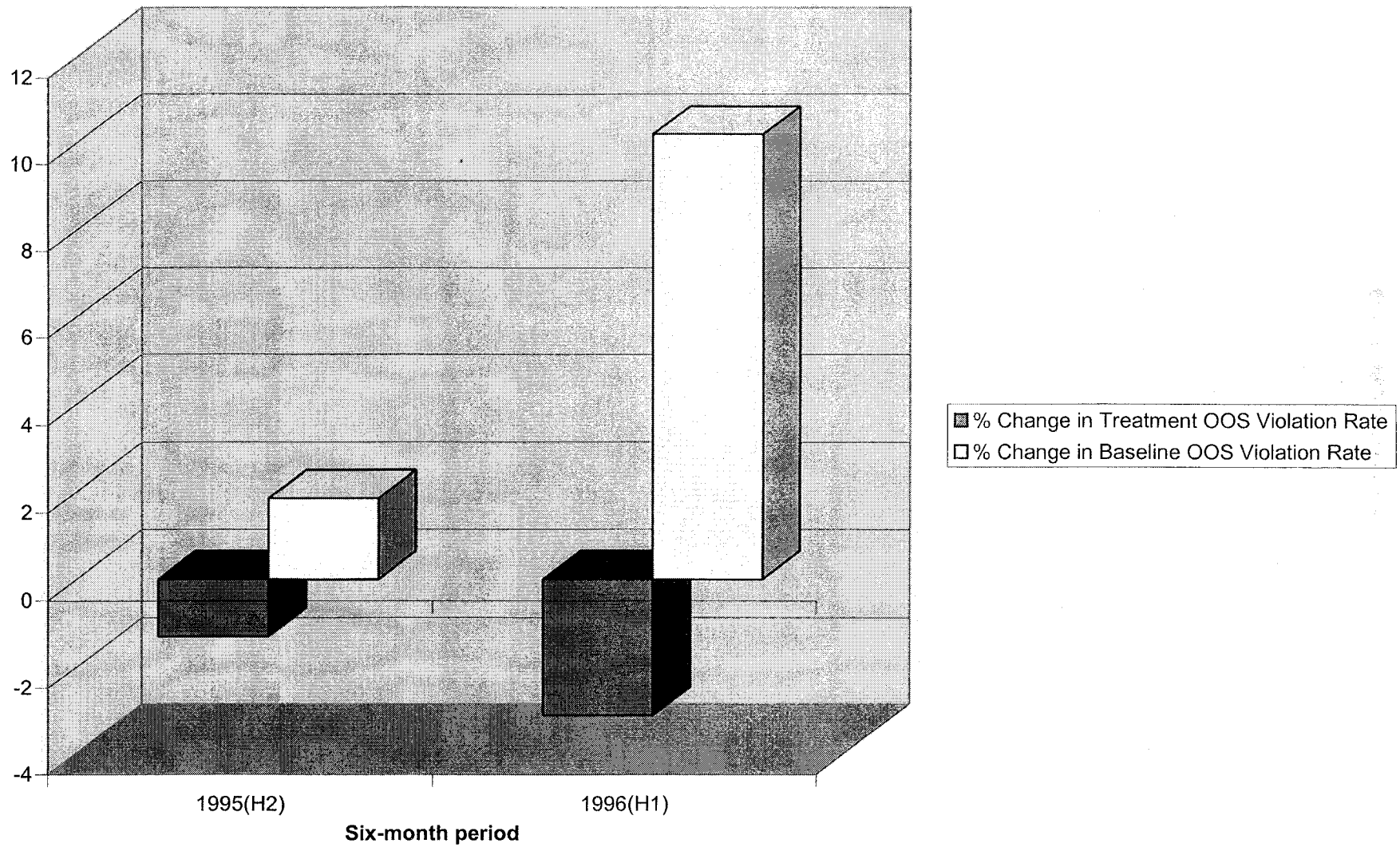


Figure 5(a): Level 2 OOS Event Rate Analysis (Long-term Effect)

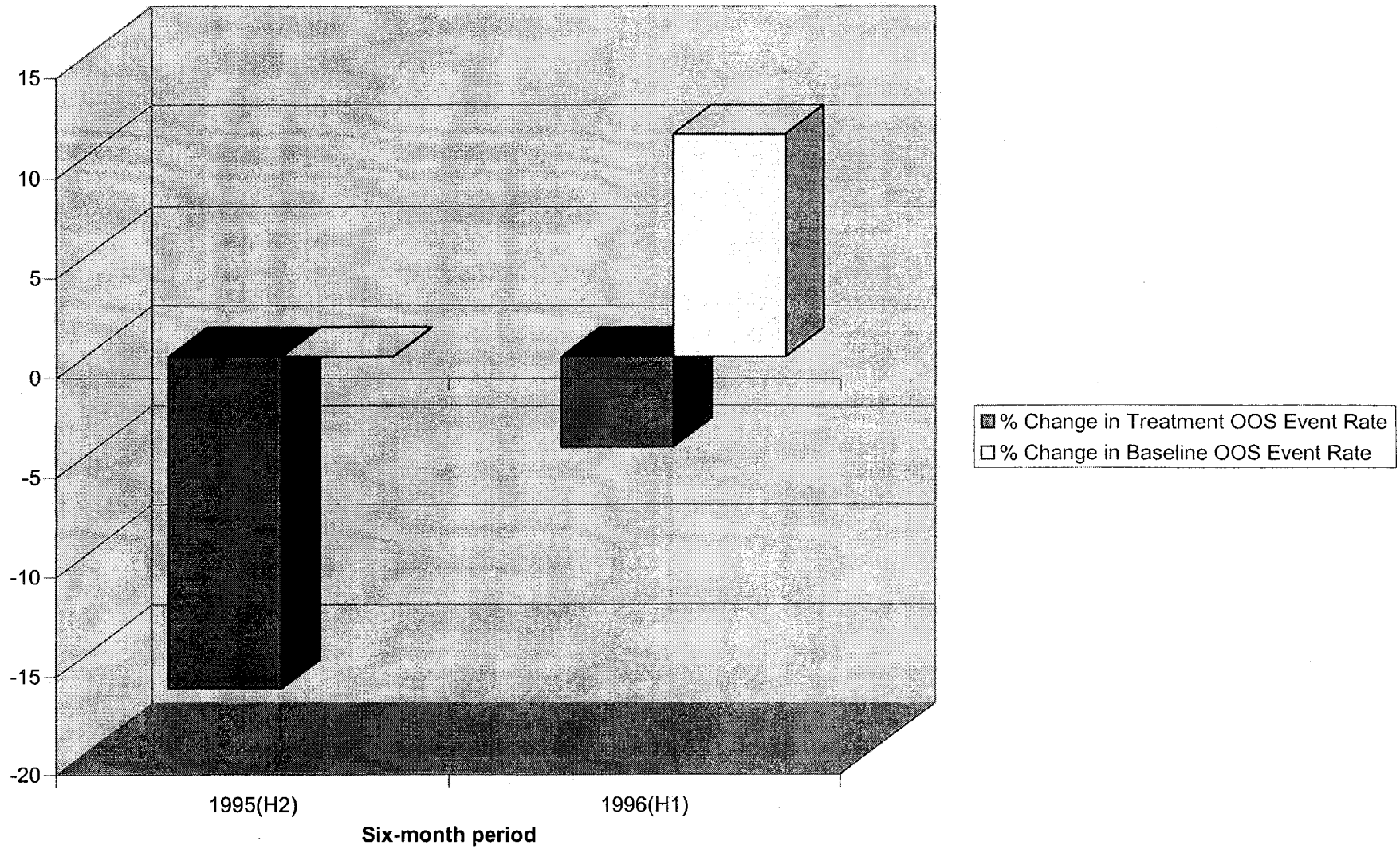


Figure 5(b): Level 2 Violation Rate Analysis (Long-term Effect)

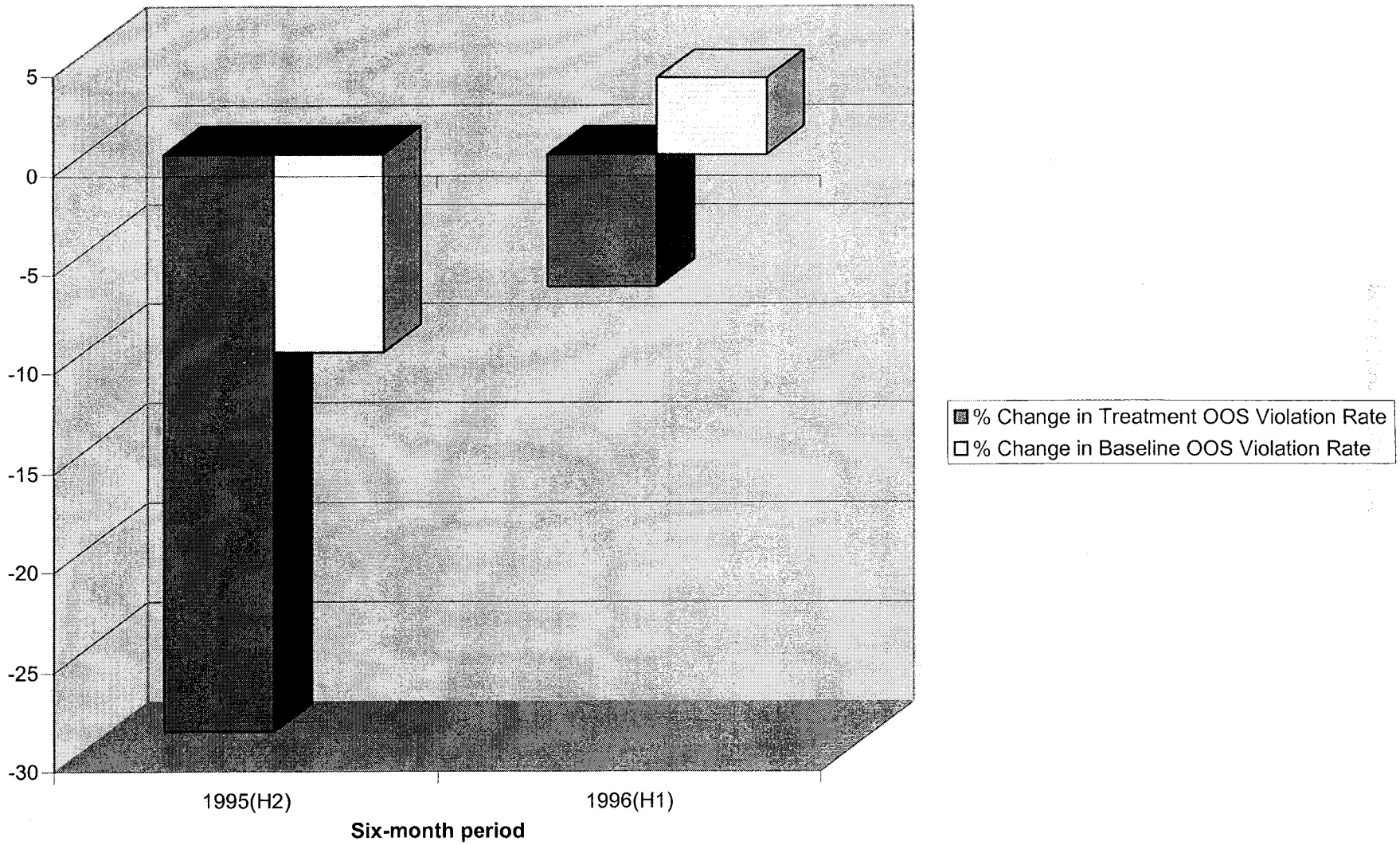


Figure 6(a): Level 3 OOS Event Rate Analysis (Long-term Effect)

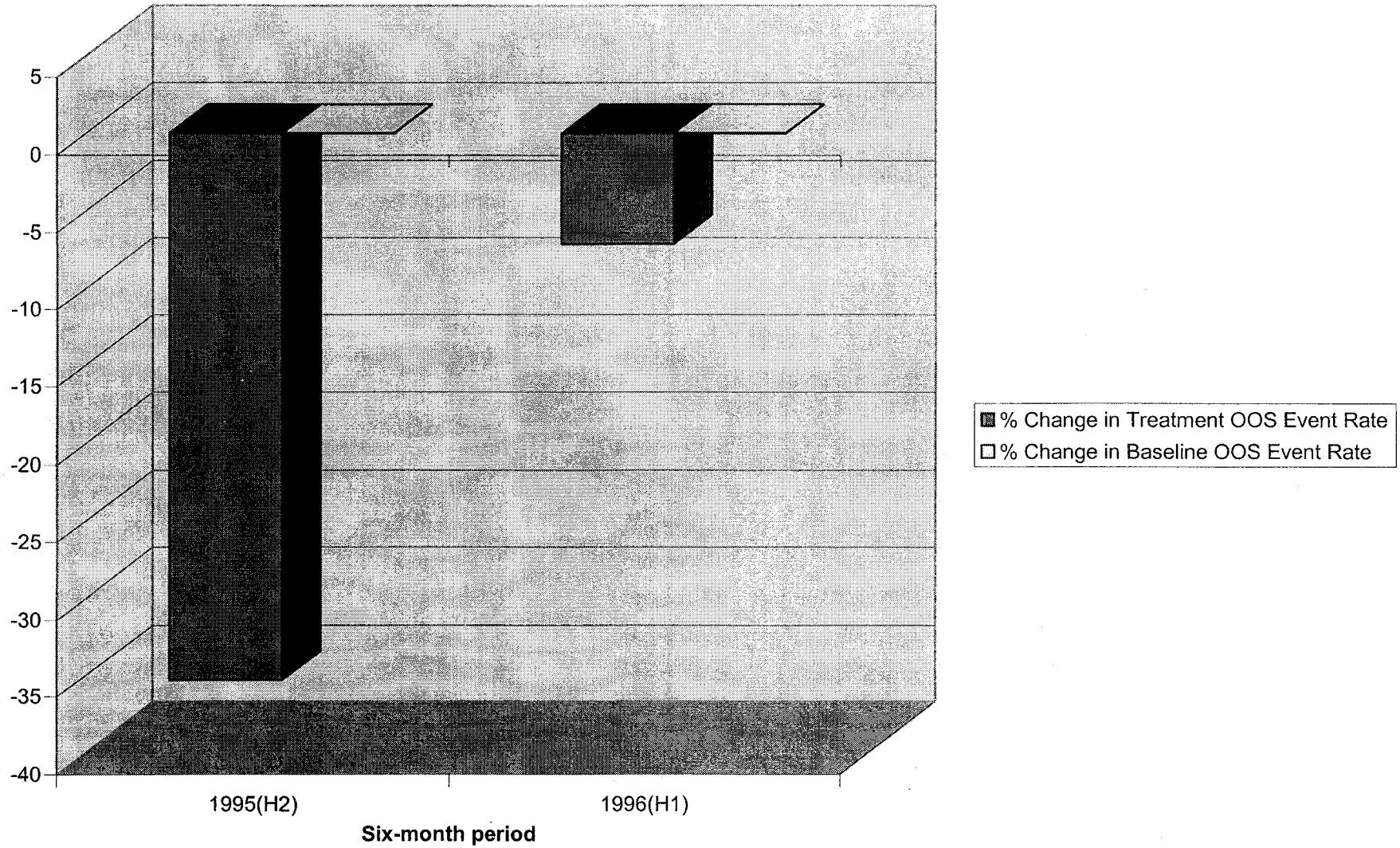
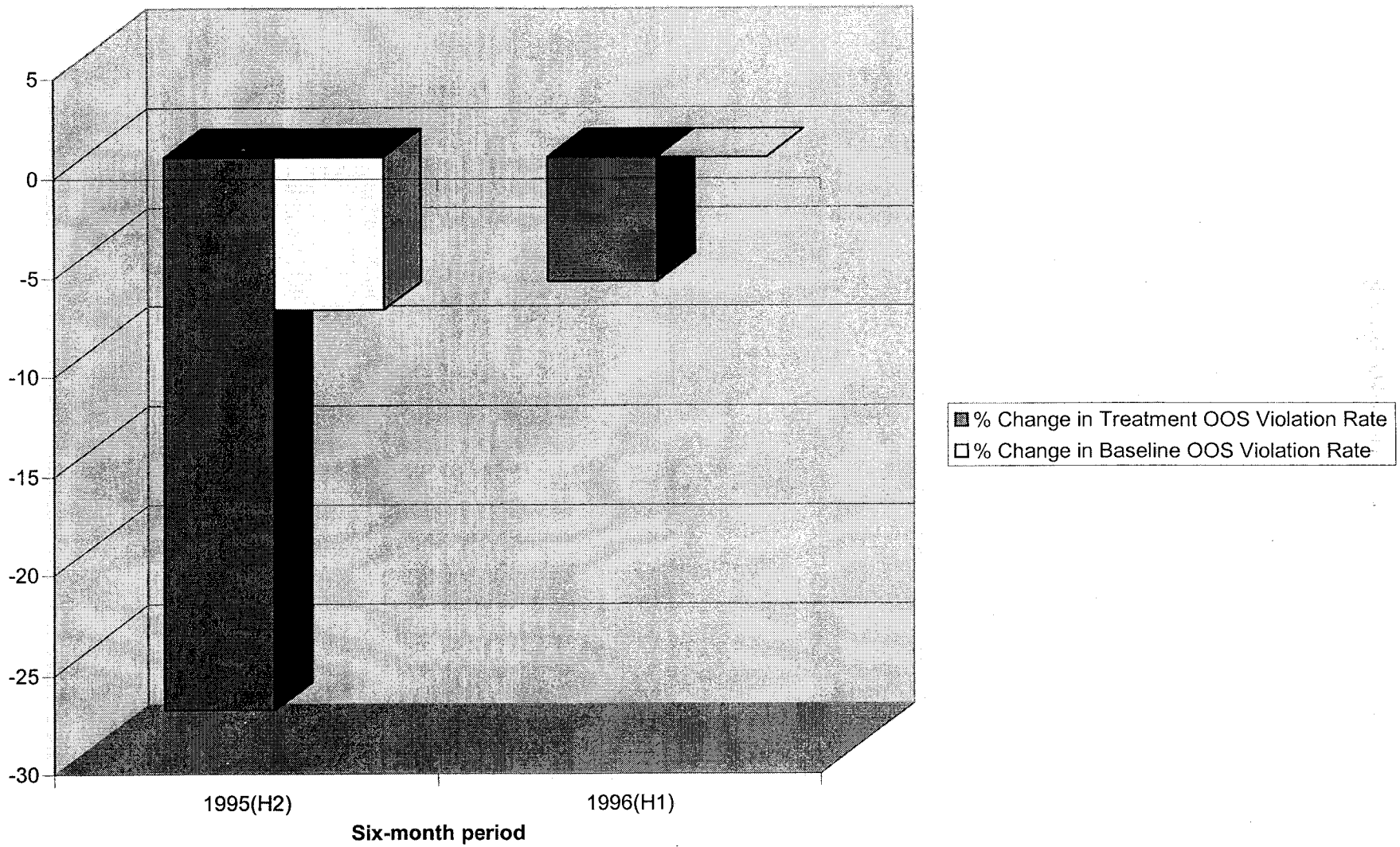


Figure 6(b): Level 3 OOS Violation Rate Analysis (Long-term Effect)



2.4 Conclusions and Recommendations

Phase I of this study was conducted only for carriers in Minnesota, and it was based upon a comparison of the absolute OOS Event and Violation rates of carriers over the same period. The decision to conduct Phase II of the study was to extend the OOS rate analysis to other Region 5 states, to check if Phase I results could be validated in this case, and to investigate the temporal characteristics of the effect of a Compliance Review, both short -term and long-term, across different levels of inspections.

Phase I findings indicated a positive correlation between the Compliance Review program for a group of carriers and the subsequent reduction in their absolute OOS rates. Another correlation discovered was between the size, mileage and hazardous material classification of a carrier and the frequency of its roadside inspections, which is detailed in the findings **[1]**.

The most distinctive characteristic of our approach in this Phase II study is that the analysis of OOS rates (comparison between treatment and baseline groups) is based on the (percentage) change in the OOS rates over a certain period and not the absolute OOS rates themselves. Due to this fact, any statistical significance tests would not be very intuitive and meaningful, in terms of comparing means of a particular quantity.

This approach is unique in that it filters out the seasonal fluctuations or trends that would invariably affect the absolute magnitudes of the OOS rates themselves. By observing and comparing the relative (percentage) changes in the OOS rates of the control and treatment groups during a particular period of time, we are able to draw reasonably accurate conclusions about the effect of the Compliance Review program. In fact, in many an instance, the absolute value of the OOS (Event/Violation) rate actually increases from one six-month period to the next, but the percentage change (increase) in the OOS rates observed in the treatment group is less than those of the control group. Added to the known fact that the candidates usually targeted for the Compliance Review program are chosen from a pool of delinquent carriers (which already have a poor track record in roadside inspections) and that carriers in the treatment group thus tend to have higher absolute average OOS rates than those in the control groups, makes it clearly visible as to why the aforementioned approach should be favored.

However, the potential efficacy of this approach could not be fully explored because of spuriously collected / interpreted inspections data for the period 1993(H2) to 1994(H2), which showed up as anomalously low average OOS event and violation rates, across all levels of inspection. This

aberration rendered this portion of data invalid for any further analysis. Only the data from 1995 onwards was actually used for the OOS rate analysis.

Results from both the short-term effect model and the long-term effects models suggest that there is an overall positive effect on the reduction of OOS rates of a particular carrier after a Compliance Review - both immediately (within the immediate six months) and after a certain latency period (of six months). The short-term effects analysis was carried out for the Private Large (PL), For-Hire Large and Medium (FL, FM) groups of carriers and the level-based longer-term effects analysis was conducted only for the For-Hire Large (FL) group of carriers, due to statistical significance considerations in terms of the sample size and the inspection rates obtained for other carrier groups. Results derived from separate short-term effects analysis of OOS rates for all carrier groups at different levels of inspection (1, 2 and 3) seem to support the above conclusion with respect to the effects of the Compliance Review program.

This study could be theoretically supplemented by investigating the effect of the Compliance Review program on the accident rates of carriers, provided there is enough data. Currently, the accident rate data of the set of carriers being studied is extremely sparse (the accident data should be expected to be inherently sparse because accidents typically occur for a small minority of carriers within the total carrier population). Thus, there is very little likelihood of obtaining any statistically significant results using accident rates as the measured effect.

Also, provided a larger population of carriers available for study, the grouping process could be further refined based on parameters other than size and segment (currently used), leading to more accurate analysis. In this case, the window size and the corresponding latency periods (in case of long-term effect model) also could be shrunk to three months or less. This would again refine the analysis of the effect of a Compliance Review, while increasing the number of windows available for study.

References

1. Cherkassky,V.S. and David Pagel (1997), Report MN/RC-97/10, "Motor Carrier Compliance Reviews : Measuring Their Impact On Improved Safety Performance Among Interstate Freight Motor Carriers Based In Minnesota" Minnesota Department Of Transportation.

2. U.S. Department Of Transportation Federal Highway Administration (1995), Federal Motor Carrier Safety Regulations Pocketbook, publisher J.J.Keller and Associates Inc.

3. Lantz, Brenda (1994), Development Of A Predictive Model To Ascertain Probable Safety Ratings For Motor Carrier Firms: A Nation-Wide Perspective, The Upper Great Plains Transportation Institute.

APPENDIX A

Description of Datasets

A-1. MASTERFL (Master Recordset File - from CENSUS Database)

Field Name	Description	Format
CENSUS_NUM	Carrier USDOT #	7 chars
CLASS	Private / For-hire / Exempt	12 chars
ORG	Carrier's Business Organization	1 char
HM	Hazardous Material Registration (if any)	1 char
TOT_PWR	total # of trucks	9-digit integer
HMTNKTRLRS	# of HM Tank Trailers	7-digit integer
HMTNKTRKS	# of HM Tank Trucks	7-digit integer
TOT_DRS	total # of drivers	5- digit integer
ACC_RATE	Accident Rate	(7.3) floating point
REPREVRAT	Preventable / Reportable Accident Rate	(7.3) floating point
ACCREPT	# of reportable accidents	5-digit integer
PREVREP	# of preventable / reportable accidents	5- digit integer
MILETOT	Total fleet miles	9- digit integer
REVDATE	Most recent review date	Date
REVDATE_2	2nd most recent review date	Date
REVDATE_3	3rd most recent review date	Date
RATRVWTYPE	Most Recent Rating Review Type	1 char
PR_PREVRAT	Prior preventable/reportable accident rate	(7.3) floating point

A-2. REVIEWFL (Compliance Review - from LAPCENS, SRCR1 and FITNESS tables)

Field Name	Description	Format
CENS_NUM	USDOT #	7 chars
REVDATE	Date the present review completed	8 chars
REVTYPE	Safety Review (S) / Compliance Review (C)	1 char
DRVLEAS	# of drivers leased per month	integer
DRF_OVER	# of drivers, interstate, over 100 miles	integer
DRS_OVER	# of drivers, intrastate, over 100 miles	integer
DRF_LOCL	# of drivers, interstate, local, within 100 miles radius	integer
DRS_LOCL	# of drivers, intrastate, local, within 100 miles radius	integer
REASON1	Initial Rating	1 char
REASON2	Complaint Investigation	1 char
REASON3	SCE Rating	1 char
REASON4	Enforcement follow up	1 char
REASON5	Carrier Request	1 char
REASON6	Other Reason	1 char
FACTOR1	Factor Score 1 (GENERAL)	1 char
FACTOR2	Factor Score 2 (DRIVER QUAL.)	1 char
FACTOR3	Factor Score 3 (OPERATIONS)	1 char
FACTOR4	Factor Score 4 (VEHICLE MAINTENANCE)	1 char
FACTOR5	Factor Score 5 (HAZMAT)	1 char
FACTOR6	Factor Score 6 (ACC. RATE)	1 char

A-3. INSPFL (Inspections File : from INSPECT table) :

Field Name	Description	Format
REPNUM	Inspection Report (1st 2 letters are state abbreviations)	10 chars
CENS_NUM	USDOT #	7 chars
LEVEL	Level of Inspection(1-5)	1 char
INSPDATE	Date of Inspection	8 chars
INSPLOC	Location of Inspection	5 chars
FACILITY	Inspection Facility Type (F / R)	1 char
TOTALVIO	Total Violations (includes non-OOS violations)	3-digit integer
TOTALOOS	Total OOS Violations	3-digit integer

APPENDIX B

Pre-Processing Algorithms

B-1. MASTERFL:

Elimination of bad records and deriving new fields for further analysis:

1. Delete all cases where miletot == 0 or tot_drs == 0 or tot_pwr == 0

   SPSS-specific command:
   Select if miletot > 0 & tot_drs > 0 & tot_pwr > 0.

2. Compute three new fields: FORHIRE, EXEMPT and PRIVATE, according to the position of X in the field CLASS (1,2 and 3/4/5 respectively).

   SPSS-specific command:
   Compute forhire = X if substr(class,1,1) == X
   exempt = X if substr(class,2,1) == X
   private = X if (substr(class,3,1) == X | substr(class,4,1) =X | substr(class,5,1) = X)

3. Compute new field SIZEPARA as the average of TOT_DRS and TOT_PWR.

   SPSS-specific command:
   Compute sizepara = (tot_drs + tot_pwr) / 2

4. Compute new field SIZE from SIZEPARA as follows:
   SIZEPARA <= 2 : SIZE = 'S'
   2 < SIZEPARA <= 15 : SIZE = 'M'
   SIZEPARA > 15 : SIZE = 'L'

   SPSS-specific command:
   Recode sizepara into size
   lowest through 2 -> 'S'
   2.01 through 15 -> 'M'
   15.01 through highest -> 'L'

5. Compute two new fields SEGMENT and SEGMNT1 (classification into Private/For-hire and Private/For-Hire/Exempt respectively).
   Note: For purposes of later analysis, the Exempt category is merged into the For-Hire category (in case of the SEGMENT field).

   SPSS-specific command:
   Recode private into segment 'X' ->'P'
   segmnt1 'X' -> 'P'
   forhire into segment 'X' -> 'F'
   segmnt1 'X' -> 'F'
   exempt into segment 'X' -> 'F'
   segmnt1 'X' -> 'E'

6. Remove all records of carrier types other than Private/For-Hire/Exempt:

SPSS-specific command:
Delete all cases where segmnt1 == ' '

7. Compute new field TYPE based on the SIZE and SEGMENT fields:

a. Recode size into type if segment = 'P'
'S' -> 'PS'
'M' -> 'PM'
'L' -> 'PL'

b. Recode size into type if segment = 'F'
'S' -> 'FS'
'M' -> 'FM'
'L' -> 'FL'

8. Compute new field AVM (total annual mileage / vehicle) = MILETOT / TOT_PWR.

SPSS-specific command:
Compute avm = miletot / tot_pwr.

9. Derive new field AVMPARA from AVM as follows:
L<15,000<H if type = 'PL'
L<20,000<H if type = 'PX', X=M,H
L<55,000<H if type = 'FL'
L<50,000<H if type = 'FM'
L<60,000<H if type = 'FS'

SPSS-specific command:

Recode avm into avmpara if type = 'PL'
lowest through 15,000 → 'L'
15,001 through highest → 'H'

Recode avm into avmpara if type = 'PM' | type = 'PH'
lowest through 20,000 → 'L'
20,001 through highest → 'H'

Recode avm into avmpara if type = 'FL'
lowest through 55,000 → 'L'
55,001 through highest → 'H'

Recode avm into avmpara if type = 'FM'
lowest through 50,000 → 'L'
50,001 through highest → 'H'

Recode avm into avmpara if type = 'FS'
lowest through 60,000 → 'L'
60,001 through highest → 'H'

B-2. REVIEWFL:

1. Delete all cases where REVTYPE is not equal to C (Compliance Review):

SPSS-specific command:
select if revtype = 'C'.

2. Compute new fields SATISF(satisfactory), CONDNL(conditional) and UNSATS (unsatisfactory) according to the review ratings determined by FACTORs 1-6.

SPSS-specific command:

```
Count factor1 - factor6 into  satisf if value = 'S' OR 'N'
                              condnl if value = 'C'
                              unsats if value = 'U'
```

3. Compute the final review rating RATING according to the individual SATISF, CONDNL and UNSATS ratings computed earlier:

SPSS-specific command:

```
Recode rating into rating
      unsats = 0 & condnl <=2 -> 'S'
      (unsats = 0 & condnl > 2) | (unsats = 1 & condnl <=2) -> 'C'
      (unsats = 1 & condnl > 2) | (unsats >=2 & condnl >=0) -> 'U'
```

4. Compute a new field HFYR as the half -year in which the Compliance Review was carried out.

SPSS-specific command:

```
Compute month = xdate.month (revdate)
Compute year = xdate.year (revdate) - 1991
Recode month into half
       lowest through 6  → 0.0
        7 through highest → 0.5
Compute hfyr = year + half.
```

B-3. INSPFL:

1. Delete all cases where TOTALOOS > 10 (Anomalous values for total # of OOS violations).

SPSS-specific command:

Select if totaloos < 11.

2. Compute new field OOSEVNT (OOS event) = 1 if the corresponding TOTALOOS field > 0.

SPSS-specific command:

Recode totaloos into oosevnt
1 through highest → 1
all other cases → 0

3. Compute a new field HFYR as the half -year in which the inspection was done. (The actual year for HFYR = x in INSPFL corresponds to the actual year for HFYR = x + 1 in REVIEWFL).

SPSS-specific command:

Compute month = xdate.month (revdate)
Compute year = xdate.year (revdate) - 1992
Recode month into half
lowest through 6 → 0.0
7 through highest → 0.5
Compute revyr = year + half.