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Administration**

Statistical Evaluation of Federal Motor Vehicle Safety Standard 105 (Passenger Car Hydraulic Brakes)

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CONTRACT TECHNICAL MANAGER'S ADDENDUM

Prepared for the National Highway Traffic Safety Administration in support of its program of regulatory reform - review of existing regulations - as required by Executive Order 12291. Agency staff will perform and publish an official evaluation of Federal Motor Vehicle Safety Standard 105 based on the findings of this report as well as other information sources. The values of effectiveness and benefits found in this report may be different from those that will appear in the official Agency evaluation.

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16. Abstract

This study investigates the effects of dual master cylinders and disc brakes which were introduced by automobile manufacturers to meet the 1968 and 1976 versions, respectively, of Federal Motor Vehicle Safety Standard 105. Regression analyses were used to determine the effects of dual master cylinders and disc brakes with respect to two performance variables:

(i) the percentage of accident-involved cars reported to have brake defects, and

(ii) the percentage of time that a car of a given class was the striking car in two-car front-to-rear crashes.

Data for the analyses were taken from North Carolina accidents occurring between 1971 and 1979.

Both dual master cylinders and disc brakes were found to be statistically significant in reducing the percentage of cars in accidents with brake defects. Neither, however, was found to be significantly associated with the percentage of striking cars in two car front-to-rear crashes.

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METRIC CONVERSION FACTORS

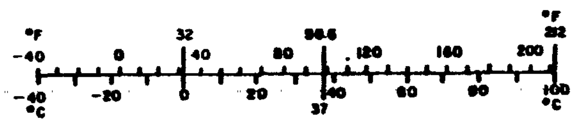
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Technical Summary

Dual master cylinders and disc brakes were introduced by automobile manufacturers to meet, respectively, the 1968 and 1976 versions of Federal Motor Vehicle Safety Standard (FMVSS) 105. Certain other braking system improvements (e.g., improved brake lining materials, proportioning and metering valves , and larger rear drums) were included on some 1975 and 1976 model year cars as a response to FMVSS 105. This study investigates the effect of these braking system changes with respect to two performance criteria:

(i) the percentage of accident involved cars reported to have defective brakes, and

(ii) the percentage of times that a car of a given class was the striking car in two-car front-to-rear crashes.

The basic data for these analyses was taken from North Carolina accidents occurring during the years 1971 through 1979 involving domestic passenger cars of 1960 and later model years. Since it was thought that driving in mountainous regions or in wet weather conditions may place more of a burden on a car's braking system, accidents occurring under either of these conditions were also analyzed separately.

The analyses involved computing the percentage of accident-involved cars having brake defects in car groups defined in terms of accident year, vehicle model year, and, in some cases, specific car make. The percentage of times that a car belonging to a given group was the striking car in a two-car front-to-rear crash was also computed for the same car groups. These two quantities (percentage with defects and percentage of striking cars) were then used as dependent variables in weighted regression analyses. Among the independent variables in the various regression models were:

- o percentage of cars (in the group) having dual master cylinders,
- o percentage of cars equipped with disc brakes,
- o percentage with power brakes,
- o car age,
- o average car weight (in pounds) for the group,
- o indicators of calendar (or accident) year,
- o indicators of specific car make.

Very good fits to the data on the percentage of cars with brake defects were provided by the regression models, and both the percentage with dual braking systems and the percentage with disc brakes were found to be highly significant with respect to this criterion. The results were quite consistent

over the three accident conditions (all accidents, hilly region accidents, and wet weather accidents).

Based upon these models Table S-1 gives values of the percentage of brake defects predicted under the three hypotheses:

H_1: no cars have either dual or disc brakes,

H_2: all cars have dual brakes but none have disc brakes,

H_3: all cars have both dual and disc brakes.

Table S-1. Predicted percentage of brake defects under H_1, H_2, and H_3.

Accident Condition	Actual P	Predicted Values $\hat{P}$ under		
		H_1	H_2	H_3
All	1.174	2.023 (.075)	1.343 (.036)	0.736 (.038)
Hilly	1.276	2.199 (.140)	1.290 (.063)	0.720 (.067)
Wet	1.017	1.453 (.128)	1.137 (.071)	0.563 (.069)

Neither dual braking systems nor disc brakes was found to be statistically significant with respect to the percentage of striking cars in two-car front-to-rear crashes. The regression models for this dependent variable contained much more unexplained variation than did those for the percent of brake defects. It might be conjectured that some of this variation may be due to a variety of driver and vehicle use variables.

No evidence was found that the other braking system improvements occurring in 1975-1976 contributed toward either reducing the percentage of brake defects in accidents, or toward reducing the percentage of striking vehicles in two-car front-to-rear crashes.

LIST OF TABLES

LIST OF TABLES (Con't)

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The author would like to express his appreciation to Dr. Charles J. Kahane, the Contract Technical Manager, for his many helpful suggestions throughout the course of this research.

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Background

Federal Motor Vehicle Safety Standard (FMVSS) 105 specifies performance requirements for passenger car brakes. In response to the 1968 version of the standard requiring a split braking system, the automobile manufacturers introduced dual master cylinders into 1962-1967 model year cars. Disc brakes were introduced by the manufacturers to meet the 1976 requirements for fade and water resistance, and, more generally, to improve vehicle handling under braking conditions.

The analyses described in this report do not constitute an evaluation of FMVSS 105 per se, but, rather, an evaluation of dual master cylinders and disc brakes.

The evaluations of dual master cylinders and disc brakes were carried out with respect to two criterion measures:

A. the percentage of cars in accidents which were indicated by the investigating officer in the accident report as having defective brakes, and

B. the percentage of cars involved in front-to-rear impacts which suffer frontal damage: an improvement in brake performance, ceteris paribus, might decrease the likelihood of being the striking (frontally damaged) vehicle in a front-to-rear crash.

Analyses with respect to criterion A are described in the next section, while those with respect to criterion B are contained in the following two sections.

Analyses of Defective Brake Incidence

The basic data for these analyses was taken from accident reports for 1971 through 1979 North Carolina accidents involving domestic passenger cars of 1960 and later model years. Vehicles were classified into accident year by model year categories to yield a table similar to that shown in Table 1. A complete description of the data processing is contained in Appendix A. The <u>ith</u> row of the table corresponds to the <u>ith</u> accident year, model year combination, $n_{\beta i}$

is the number of vehicles in the ith category having defective brakes, n_{oi} is the number having no defect or some other defect, $N_i = n_{\beta i} + n_{oi}$, and $P_{\beta i} = \frac{n_{\beta i}}{N_i} \times 100$ is the percentage of cars in the ith category having brake defects. The percentages were then analyzed to determine the manner in

Table 1. Defective Brake Rates

Accident Year	Model Year	Vehicle Defect		
		Brakes	None or Other	Total
1971	1960	$n_{\beta 1}$	n_{o1}	N_1
	.	P_1	$1-P_1$	.
.	.	.	.	.
.	.	.	.	.
.	1971	.	.	.
1972				
.				
.				
.				
1979				

which they responded to changes in the percentages of cars in the fleet having dual master cylinders, and to the percentage having disc brakes.

Since the totals, N_i, vary considerably over the accident year by model year categories, weighted regression analyses were used to estimate the effects of the brake variables. In particular, the observations for the ith category were weighted by the quantity $\frac{N_i}{P_i\,(100-P_i)}$, the inverse of the variance of P_i. In addition to the percentage of cars having dual master cylinders, and the percent having disc brakes, the other independent variables that were used in the regression analyses were:

- o the age of the vehicle, (i.e. acc. year - mod. year +1),
- o indicators of accident year,
- o average vehicle weight for the fleet, (in pounds),

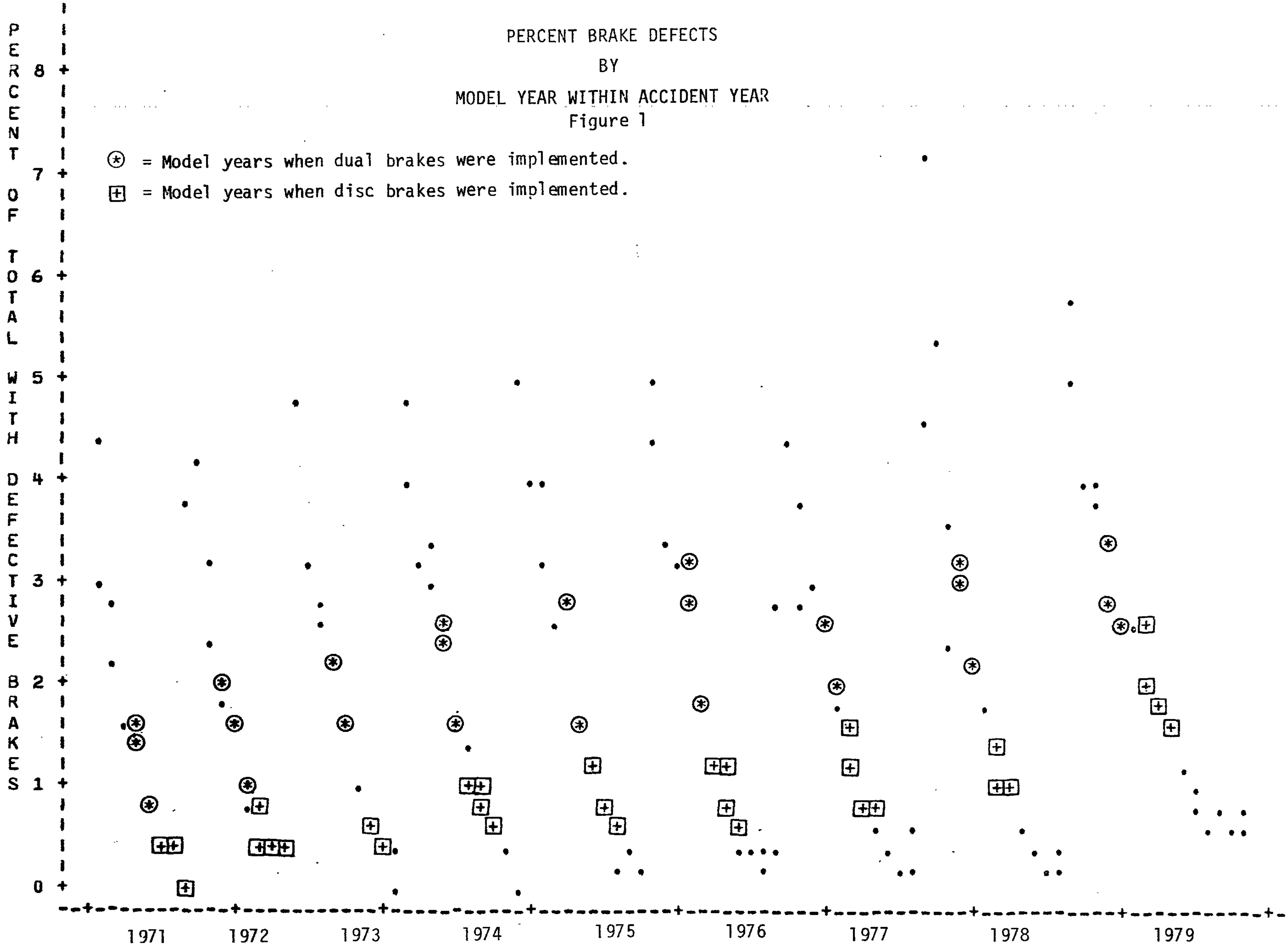
o the percent of the fleet with power brakes.

The average vehicle weight was calculated for each combination of accident year and model year as the sample mean of the weights of those vehicles involved in accidents. Values of the fleet percentages for power brakes, disc brakes, and dual master cylinders are shown below in Table 2 by model year. A complete listing of the remaining variables is given in Appendix B.

Table 2. Percentages with Disc Brakes, Power Brakes, and Dual Master Cylinders.

Model Year	Power	Disc	Dual M.C.
1960	26.3	0	0
1961	24.3	0	0
1962	25.7	0	9
1963	27.1	0	9
1964	29.3	0	7
1965	32.3	2.2	7
1966	35.3	2.9	unknown
1967	40.6	6.1	100
1968	41.7	12.7	100
1969	49.3	27.8	100
1970	50.9	41.0	100
1971	56.7	63.1	100
1972	68.0	73.6	100
1973	75.5	85.7	100
1974	67.3	84.1	100
1975	75.9	92.6	100
1976	80.9	98.8	100
1977	86.9	100	100
1978	85.1	100	100
1979	82.9	100	100
1980	61.7	100	100

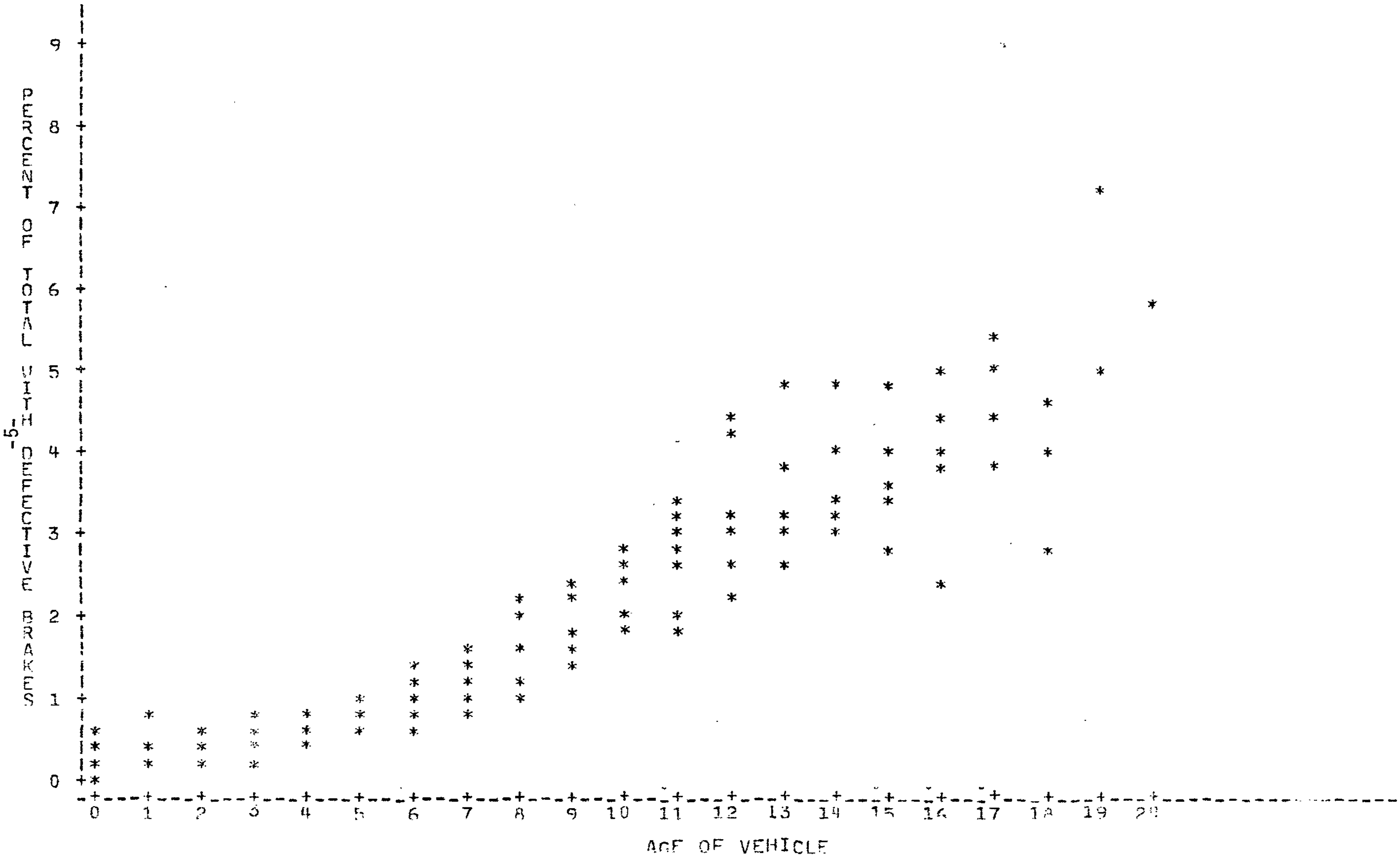
Plots of the data revealed that for each accident year, the percentage of brake defects increased dramatically with earlier model year cars. Figure 1, for example, shows a plot of the percentage of brake defects plotted in increasing order of model year within accident year. The reduction in the brake defect rate is generally quite dramatic for model years 1965-1967 (indicated by ⊛) when dual brakes were implemented, and again during 1969-1972 when disc brakes were implemented (denoted by ⊞). This is followed by a leveling off period. Figure 2 shows the relationship between the percentage of brake defects and



NOTE: 19 OBS HIDDEN

PERCENT BRAKE DEFECTS
BY
VEHICLE AGE

Figure 2



NOTE: 65 OBS HIDDEN

vehicle age. Thus, it appeared that the brake defect rate might be strongly related to vehicle age, and possibly the brake variables.

Initial regression analyses were run (using the SAS GLM Procedure) using both linear and log linear models, and including all of the independent variables listed above. Accident year was entered as a class variable with nine levels. Refinements to the models were made by omitting non-significant variables, by grouping similar levels of class variables, and by considering various potential interaction terms.

Another concern was with the sensitivity of the models to the unknown 1966 value of the percentage of cars with dual master cylinders. The available information seemed to indicate that this value should be somewhere between 7 percent and 49 percent. Table 3 shows results for a sequence of linear models using dual brake values in that range. As the results show, the regressions were quite insensitive to the 1966 dual brake value, and, in fact, the results were essentially unchanged when the 1966 data was omitted from the analysis. This was done in all subsequent analyses.

Table 3. Regression results (F and p values)

Percent Dual Brake (1966)	8 d.f. Acc. Yr.	Age	Wt.	Dual Brakes	Disc Brakes	Power Brakes	R
7%	6.53 (.0001)	67.03 (.0001)	13.73 (.0003)	122.37 (.0001)	3.65 (.0582)	0.47 (.4955)	.939
14%	6.69 (.0001)	65.46 (.0001)	13.92 (.0003)	126.62 (.0001)	4.19 (.0426)	0.52 (.4735)	.940
28%	6.93 (.0001)	62.26 (.0001)	14.43 (.0002)	132.45 (.0001)	5.32 (.0226)	0.63 (.4297)	.942
35%	6.99 (.0001)	60.69 (.0001)	14.75 (.0002)	133.39 (.0001)	5.85 (.0168)	0.69 (.4091)	.942
49%	6.93 (.0001)	57.85 (.0001)	15.51 (.0001)	130.03 (.0001)	6.68 (.0108)	0.80 (.3739)	.941

As may be noted from Table 3 the effects of accident year, vehicle age, dual braking systems, and disc brakes were generally quite significant, while power brakes was not. Moreover, the fit of the models (as measured by R^2) was quite good. These same results held for most of the models considered.

The number of accident year classes was reduced from nine to four by combining accident years 1973-1978. Accident year differences between 1972 and 1973, and between 1978 and 1979 correspond to changes in the accident reporting form. A significant difference was also found, however, between the 1971 and 1972 accident years.

Following this collapsing of accident year classes and the omission of the power brakes variable, weighted residuals were calculated and plotted against the dependent variable, each independent variable, and in model year within accident year sequence. The plots showed that the model systematically underestimated the largest values of the dependent variable. These values usually corresponded to the earliest model year cars. This suggested that a higher order age term might improve the model. As it turned out a second order age term was found to be highly significant, and the inclusion of the second order term caused the linear age effect to no longer be significant.

The residuals from the linear model with the second order age effect did not indicate any model misspecification, so that model was selected as the final model to assess the effects of dual master cylinders and disc brakes on the percentage of cars in accidents with brake defects. The results are shown in Table 4. The model, thus, shows that there were some significant accident year differences, that the percentage of brake defects increases approximately as the square of the age of the car, that heavier cars have slightly lower brake defect rates, and that both dual master cylinders and disc brakes contributed significantly toward the reduction of the percentage of brake defects.

In addition to the analysis described above which dealt with the brake defect rate for all North Carolina accidents, two other analyses were carried out, each of which dealt with a subset of these accidents. These subsets were:

- accidents occurring in hilly regions of the state, and
- accidents occurring in wet weather conditions.

Table 4. Model for Defective Brake Incidence

Effect	DF	F-Value	P
Accident year	3	33.58	.0001
$(Age)^2$	1	270.29	.0001
Vehicle Weight (pounds)	1	7.41	.0512
Dual Brakes (percent)	1	93.59	.0001
Disc Brakes (percent)	1	83.61	.0001

Parameter		Estimate	
Constant		2.629	
Acc. Yr.	1971	-.619	
	1972	-.487	$R^2 = .96$
	73-78	-.357	
$(Age)^2$		.010	
Vehicle Weight (pounds)		-.0002	
Dual Brakes (percent)		-.007	
Disc Brakes (percent)		-.006	

In both of these cases essentially the same procedures were followed in developing the final models as were used in the all accidents case. These procedures led to the models shown in tables 5 and 6.

Table 5. Model for Defective Brake Incidence in Hilly Region Accidents

Effect	DF	F Value	P
Accident year	2	11.89	.0001
$(Age)^2$	1	63.93	.0001
Dual Brakes (percent)	1	40.13	.0001
Disc Brakes (percent)	1	26.51	.0001

Parameter		Estimate	
Constant		2.107	
Acc. Yr.	71	-.601	$R^2 = .83$
	72-78	-.397	
$(Age)^2$		.009	
Dual Brakes (percent)		-.009	
Disc Brakes (percent)		-.006	

Table 6. Model for Defective Brake Incidence in Wet Weather Accidents.

Effect	DF	F-Value	P
Accident year	2	9.77	.0001
Age	1	26.32	.0001
$(Age)^2$	1	7.43	.0073
Dual Brakes (percent)	1	5.82	.0172
Disc Brakes (percent)	1	21.09	.0001

Parameter		Estimate	
Constant		1.226	
Acc. Yr.	1971	-.563	
	72-78	-.299	$R^2 = .70$
Age		.122	
$(Age)^2$		-.004	
Dual Brakes (percent)		-.003	
Disc Brakes (percent)		-.006	

A comparison of tables 4 and 5 shows that the models for brake defects in all accidents and in hilly region accidents are quite similar. For the hilly region accidents the effect for accident year 1972 has been combined with that for years 1973-1978, and the effect of car weight, marginally significant in the all accident model, was not significant for hilly region accidents. Otherwise, the model coefficients remained quite similar, although the magnitude of the coefficient for dual brakes increased from .007 to .009.

Table 6 shows that the model for brake defects in wet weather accidents differs somewhat more from the other two. This model contains a linear age effect, and the magnitude of the coefficient for dual brakes has dropped to .003. The coefficient for disc brakes, however, remained the same.

In addition to providing a mechanism for testing the significance of the brake related variables, the regression models were also used to provide estimates of the overall percentage of cars in accidents that would have had brake defects under the following three hypotheses.

H_1: No cars have either dual braking systems or disc brakes.

H_2: All cars have dual brakes, but none have disc brakes.

H_3: All cars have both dual brakes and disc brakes.

Using the model given in Table 4 the percentage of cars of model year j, predicted to have brake defects in accident year i accidents, is given by the expression,

$$\hat{P}_{ij} = \hat{\beta}_o + \hat{\beta}_{yi} + \hat{\beta}_4 (i-j+1)^2 + \hat{\beta}_5 (w_{ij}), \quad (1)$$

under H_1, where $\hat{\beta}_o$ is the intercept, $\hat{\beta}_{yi}$ is the appropriate accident year i effect, $\hat{\beta}_4$ and $\hat{\beta}_5$ are the coefficients of vehicle age squared and vehicle weight respectively, and w_{ij} is the average weight of model year j cars in accident year i accidents. The overall percentage of brake defects in accident year i is given by,

$$\hat{P}_i = \sum_i \alpha_{ij} \hat{P}_{ij} , \quad (2)$$

where $\alpha_{ij} = n_{ij}/n_i$, n_{ij} is the number of model year j cars involved in accidents in year i, and n_i is the total number of vehicles in accidents in year i. Finally, the overall percentage of brake defects in accident years 1971-1979 is obtained from the expression,

$$\hat{P} = \sum_i \alpha_i \hat{P}_i \quad (3)$$

where $\alpha_i = \frac{n_i}{n}$, and $n = \sum n_i$. Substituting (1) into (2), and (2) into (3) and expanding yields the expression,

$$\hat{P} = \hat{\beta}_o + \frac{n_{71}}{n} \hat{\beta}_1 + \frac{n_{72}}{n} \hat{\beta}_2 + \frac{(n_{73} + \dots + n_{78})}{n} \hat{\beta}_3$$

$$+ \sum_{ij} \frac{n_{ij}}{n} (i-j+1)^2 \hat{\beta}_4 + \sum_{ij} \frac{n_{ij}}{n} w_{ij} \hat{\beta}_5$$

$$= \hat{\beta}_o + C_1 \hat{\beta}_1 + C_2 \hat{\beta}_2 + C_3 \hat{\beta}_3 + C_4 \hat{\beta}_4 + C_5 \hat{\beta}_5.$$

The constants $C_1, \dots C_5$ can be computed from the data and input to the GLM program which will then provide an estimate of $\hat{P}$ as a linear function of the regression coefficients. GLM also provides an estimate of the standard error of

$\hat{P}$. Under H_2 and H_3 the terms 100 $\hat{\beta}_6$ and 100 $\hat{\beta}_7$ are, respectively, added to the expression for P.

Table 7 gives estimates of P under each of the three hypotheses for each of the three accident conditions. Standard errors (in parentheses) of the $\hat{P}$'s are also given as is the actual overall percentage of brake defects.

Table 7. Predicted percentage of brake defects under H_1, H_2, and H_3.

Accident Condition	Actual P	Predicted Values $\hat{P}$ under		
		H_1	H_2	H_3
All	1.174	2.023 (.075)	1.343 (.036)	0.736 (.038)
Hilly	1.276	2.199 (.140)	1.290 (.063)	0.720 (.067)
Wet	1.017	1.453 (.128)	1.137 (.071)	0.563 (.069)

Thus, under H_2 the predicted percentage of brake defects is 28% less than it is under H_1 for all accidents. Under H_3 the percentage is 52% less than under H_1, and 33% less than under H_2. Since the actual observed percentage of brake defects was derived from a fleet of cars (some having both dual braking systems and disc brakes, some having neither, and some having one but not the other) this value falls between those predicted under H_1 and H_3. Similar results hold for the other accident conditions.

Analysis of Two-Car Front-Rear Accidents

A second criterion for examining the effects of dual brakes and disc brakes was to determine how the percentage of times that a car of a particular class was the striking car in two car, front-to-rear crashes, varied with the percentage of cars of that class equipped with dual master cylinders and disc brakes. The idea here is that if a given class of cars is equipped with brakes that are in some way superior to those of cars of other classes, then the probability that a car of this class will be the striking car in a two car front-to-rear crash should be somewhat less than a similar probability for a car of another class. Two sets of analyses were done with respect to this criterion. The first of these involved domestic passenger cars of model years from 1967 to 1979. Cars were classified by calendar accident year, model year, and car make. Preparation of the basic data for these analyses is described in Appendix A.

Since the data was not sufficient in quantity for the examination of each specific car make (e.g., Dodge Polara, AMC Gremlin, etc.) it was necessary to form groups of car makes to be analyzed together. Using information taken from Ward's Automotive Yearbooks for the years 1967-1979, specific car makes were grouped together for each model year under the following general guidelines.

a) Car types were combined that were most similar with respect to car weight, the percent having disc brakes, and the percent having power brakes.

b) Car types were combined first within manufacturers (e.g., Chevrolets + Pontiacs, etc.), and across manufacturers if necessary.

c) Car types with very low frequencies were combined with others if they seemed to fit, or were dropped from consideration if they did not.

d) After the classes had been formed for each model year they were modified to some extent to make them as consistent as possible across model years.

This process resulted in 20 car classes which are listed in Table 8. The percent of cars in each class having disc brakes and power brakes were computed (by model year), also using information from Ward's Automotive Yearbook. Prior to 1972, figures were not given for the percentage of cars having power disc brakes, although the percentage for power drum brakes was given. For these cars the percentage with power disc brakes was estimated as the product of the

Table 8. Car make/model groups by model year.

Model Year	Car Class 1	2	3	4	5
1979	Chevrolet	Pontiac LeBaron Diplomat	Camaro Firebird	Mustang	Chevelle/Malibu LeMans
1978	Chevrolet	Pontiac LeBaron Diplomat	Camaro Firebird	Mustang	Chevelle/Malibu LeMans
1977	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang	Chevelle LeMans
1976	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang	Chevelle LeMans
1975	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang II	Chevelle LeMans
1974	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang II	Chevelle LeMans
1973	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang	Chevelle LeMans
1972	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang, Barracuda Challenger, Metador	Chevelle LeMans
1971	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang, Cougar	Chevelle LeMans
1970	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang, Cougar, AMX/Javelin	Chevelle Tempest
1969	Chevrolet	Pontiac/GP	Camaro Firebird	Mustang	Chevelle Tempest
1968	Chevrolet	Pontiac	Camaro Firebird	Mustang	Chevelle Tempest
1967	Chevrolet	Pontiac	Camaro Firebird	Mustang	Chevelle Tempest

Model Year	Car Class 6	7	8	9
1979	Cutlass Century/Skylark	Monte Carlo Concord	Nova/Citation Phoenix	Oldsmobile, LeSabre/Electra
1978	Cutlass Century/Skylark	Monte Carlo Concord	Nova/Citation Phoenix	Oldsmobile, LeSabre/Electra
1977	Cutlass Century/Skylark	Monte Carlo	Nova, Omega, Ventura	Oldsmobile, Buick
1976	Cutlass Century/Skylark	Monte Carlo	Nova, Omega, Ventura	Oldsmobile, Buick, Riviera
1975	Cutlass Century	Monte Carlo	Nova, Ventura, Omega, Apollo	Oldsmobile, Buick, Riviera
1974	Cutlass Century Ambassador	Monte Carlo	Nova, Ventura, Omega, Apollo	Oldsmobile, Buick, Riviera, Mercury, Chrys.
1973	Cutlass Century Ambassador	Monte Carlo	Nova, Ventura II	Oldsmobile, Buick, Riviera
1972	Cutlass Century Ambassador	Monte Carlo	Nova, Ventura II	Oldsmobile, Buick, Riviera
1971	F-85, Skylark	Monte Carlo	Nova, Ventura II	Oldsmobile, Buick, Riviera
1970	F-85, Buick Special	Monte Carlo	Nova, Rebel	Buick, Riviera, Chrysler
1969	F-85, Special		Nova	Oldsmobile, Buick, Riviera, Chrysler
1968	F-85, Special			Olds., Buick, Cadillac, Chrys.
1967	F-85, Special			Olds., Buick, Cadillac, Chrys.

Model Year	Car Class 10	11	12
1979	Cadillac, Lincoln, T-Bird	Monza, Sunbird, Fairmont, Zephyr	Pinto, Bobcat
1978	Cadillac, Lincoln, T-Bird	Monza, Sunbird, Fairmont, Zephyr	Pinto, Bobcat
1977	Cadillac, Lincoln, T-Bird	Monza, Maverick, Astre, Comet, Sunbird	Pinto, Bobcat
1976	Cadillac, T-Bird, Lincoln, Toronado	Monza, Sunbird, Maverick	Pinto
1975	Cadillac, T-Bird, Lincoln, Toronado	Monza, Maverick	Pinto
1974	Cadillac, T-Bird, Toronado, Lincoln, Imperial	Maverick	Pinto
1973	Cadillac, T-Bird, Lincoln, Imperial, Toronado	Maverick	Pinto
1972	Cadillac, T-Bird, Toronado, Lincoln, Imperial	Maverick	Pinto
1971	Cadillac, T-Bird, Toronado, Lincoln, Imperial	Maverick	
1970	Olds., Toronado, Cadillac, T-Bird, Lincoln, Imperial	Maverick	
1969	Cadillac, T-Bird, Lincoln, Imperial		
1968	T-Bird, Lincoln, Imperial		
1967	T-Bird, Lincoln, Imperial		

Model Year	Car Class 13	14	15
1979	LTDII, Granada, Cougar/XR7, Chrysler/ Cordoba, Monarch	LTD, Marquis	
1978	LTDII, Granada, Cougar/XR7, Chrysler/ Cordoba, Monarch	LTD, Marquis	Fury, Monaco, Magnum
1977	LTDII, Granada Cougar/XR7, Monarch	Ford, Marquis	Fury, LeBaron Monaco, Charger, Diplomat
1976	Torino, Granada, Cougar, Monarch, Montego	LTD, Marquis	Fury, Coronet, Charger, S.E.
1975	Torino, Granada, Montego, Monarch, Cougar	LTD	Fury, Coronet, Matador, Charger, S.E.
1974	Torino, Montego, Cougar	Ford	Satellite, Coronet/Charger
1973	Torino, Montego	Ford	Satellite, Coronet/ Charger, Cougar
1972	Torino, Montego	Ford	Satellite, Coronet/ Charger, Cougar
1971	Torino, Montego	Ford	Satellite, Coronet/Charger
1970	Fairlane/Torino, Montego	Ford, Mercury	Belvedere, Coronet, Charger, Challenger, Barracuda
1969	Fairlane, Montego, Cougar	Ford, Mercury	Belvedere, Coronet, Charger, Barracuda
1968	Fairlane, Cougar	Ford, Mercury	Belvedere, Coronet, Charger, Barracuda
1967	Fairlane, Cougar	Ford, Mercury	Belvedere, Coronet, Charger, Barracuda

Model Year	Car Class 16	17	18	19	20
1979		Chevette, Horizon, Omni		Volare, Aspen	
1978		Chevette, Horizon, Omni		Volare, Aspen	
1977	Gran Fury, Royal Monaco, Chrysler/ Cordoba	Chevette	Gremlin, Hornet, Pacer	Volare, Aspen	
1976	Gran Fury, Chrysler/ Cordoba, Monaco	Vega, Astre, Chevette	Gremlin, Hornet, Pacer		
1975	Gran Fury, Chrysler/ Cordoba, Monaco	Vega, Astre	Comet, Valiant, Dart, Pacer, Hornet		
1974	Fury, Monaco	Vega	Comet, Hornet, Gremlin	Valiant, Dart	
1973	Fury, Polaro	Vega	Comet, Hornet, Gremlin	Valiant, Dart, Javelin	Mercury, Chrysler
1972	Fury, Polaro	Vega	Comet, Hornet, Gremlin	Valiant, Dart, Javelin	Mercury, Chrysler
1971	Fury, Polaro	Vega	Comet, Hornet, Gremlin	Valiant, Dart, Javelin	Mercury, Chrysler
1970	Fury, Polaro, Ambassador		AMC	Valiant, Dart	
1969	Fury, Polaro		AMC	Valiant, Dart, Falcon	
1968	Fury, Polaro		AMC	Valiant, Dart, Falcon, Chevy II	
1967	Fury, Polaro			Valiant, Dart, Falcon, Comet, Chevy II	

percent with power steering times the percent with disc brakes. These variables were then entered into the data set so that the analyses could proceed. The data set, thus, consisted of the criterion or dependent variable which was the percentage of striking vehicles (cars with frontal damage) in two car front-to-rear accidents for each combination of accident year, model year, and car class. The potential independent variables were:

- o indicators of accident year,
- o indicators of car class,
- o vehicle age (acc. year - mod. year +1),
- o average vehicle weight in pounds for the class (by model year),
- o precentage of cars with disc brakes,
- o percentage of cars with power brakes.

Initial plots of the variables did not reveal any noticeable relationships between the dependent and independent variables, with the one exception that the percentage of striking cars seemed to vary systematically with car class.

Regression analyses tended to confirm these findings. Car class was, by far, the dominant factor in modelling the the percent of cars with frontal damage. Car age was also significantly related to the dependent variable, but none of the other variables were. Table 9 shows some results from a linear regression to investigate the effects of car class, age, and the brake variables. The variables indicating accident year and vehicle weight had been dropped from the model due to their nonsignificance in earlier models. Table 9 does not show the estimates of the twenty car class parameters.

A model with car class alone fit the data nearly as well with a value of R^2 of .252. Table 10 shows the predicted values of the percentage of frontal impacts for each of the car classes from this model (car class alone). As can be seen, the predicted values from this model cover a fairly wide range.

Table 9. Regression analysis of front-to-rear crashes.

Source	D.F.	Sum of Squares	F-Value	P
Car Class	19	600.54	21.73	.0001
Age	1	46.94	32.26	.0001
$(Age)^2$	1	37.69	25.91	.0001
Disc Brakes	1	1.09	0.75	.3877
Power Brakes	1	3.86	2.66	.1034

Parameter	Estimate	
Age	-1.145	
$(Age)^2$	0.084	R^2 = .276
Disc Brakes	-0.006	
Power Brakes	0.017	

Table 10. Predicted percentage of frontal impacts.

Car Class	Make/Model Example*	Percentage of Frontal Impacts
1	Chevrolet	48.31
2	Pontiac	49.84
3	Camaro	56.88
4	Mustang	52.21
5	Chevette	50.50
6	Cutlass	49.30
7	Monte Carlo	54.36
8	Nova	49.18
9	Olds	44.31
10	Cadillac	47.58
11	Maverick	51.09
12	Pinto	56.18
13	Torino	47.23
14	Ford	48.73
15	Charger	48.05
16	Fury	44.56
17	Vega	55.94
18	Gremlin	52.43
19	Valiant	48.00
20	Chrysler	44.99

*The complete class compositions are given in Table 8.

Models containing interactions of the brake variables with each of the other variables were also tested, but none of these yielded any consistently significant and meaningful effects for the brake related variables.

It would seem, then, that with respect to all front-to-rear accidents the percentage of cars with frontal damage depends strongly on car class (which may be a proxy measure for certain characteristics of the driver, and the use to which the vehicle is put). The percentage also varies to some extent with car age, but does not seem to be associated with the percentage of cars in the class having disc brakes, or with the percentage having power brakes.

Again, as was the case with brake defects, two additional analyses were done for the front-to-rear accident subsets consisting of accidents occurring in hilly regions of the state, and accidents occurring in wet weather conditions. Only car class had a significant effect on the percentage of cars with frontal impacts in hilly region accidents. Table 11 shows results from a model that included effects of class, age, disc brakes, and power brakes that was fit to the hilly region data. When class was the only effect included it became significant with an F-value of 1.81 and P = .02. Neither of the brake variables, however, showed any significant effects with respect to the percentage of frontal impacts in hilly regions.

Table 11. Model for front-to-rear crashes in hilly regions.

Source	D.F.	Sum of Squares	F-Value	P
Class	18	35.30	1.54	.0729
Age	1	0.70	0.55	.4591
Disc Brakes	1	0.01	0.01	.9160
Power Brakes	1	1.42	1.12	.2908

Parameter	Estimate	
Age	-0.175	
Disc Brakes	0.003	R^2 = .082
Power Brakes	-0.048	

In wet weather accidents the effects of car class, age, and power brakes were all significant, while that for disc brakes was not. Table 12 shows results for a model containing all of these effects. When the disc brake variable was omitted from the above model the effect of power brakes became much more significant with an F-Value of 5.68 and P = .0174. The model coefficient for power brakes was $\hat{\beta}_p = -.035$.

Table 12. Model for front-to-rear crashes in wet weather.

Source	D.F.	Sum of Squares	F-Value	P
Class	19	77.49	3.50	.0001
Age	1	14.46	12.40	.0005
(Age)^2	1	11.44	9.81	.0018
Disc Brakes	1	0.24	0.20	.6510
Power Brakes	1	4.27	3.67	.0559

Parameter	Estimate
Age	-1.571
(Age)^2	0.117
Disc Brakes	0.007
Power Brakes	-0.043

$R^2 = .133$

In summary, the analyses of recent model year cars in two-car front-to-rear accidents showed that the percentage of striking cars varied considerably with car class for all three accident conditions. Car age was found to be a significant factor when all accidents were examined, and also for accidents occurring in conditions of wet weather. In wet weather accidents the percentage of cars having power brakes was also significant. The percentage of cars having disc brakes was not significant in any of the analyses. In general, the regression models accounted for relatively small amounts of the variation within the data, with R^2's ranging from only .28 for the all accidents to .08 for accidents in hilly regions.

The second part of the front-to-rear accident analysis dealt with earlier model cars -- 1960 through 1969 model years. These cars were not classified by specific makes, but were simply grouped by model year and accident year. The dependent variable was the percentage of cars in the group that had frontal damage, while the potential independent variables were:

- o indicators of accident year,
- o car age,
- o average vehicle weight,
- o the percent of cars in the group with dual master cylinders, and
- o the percent having power brakes.

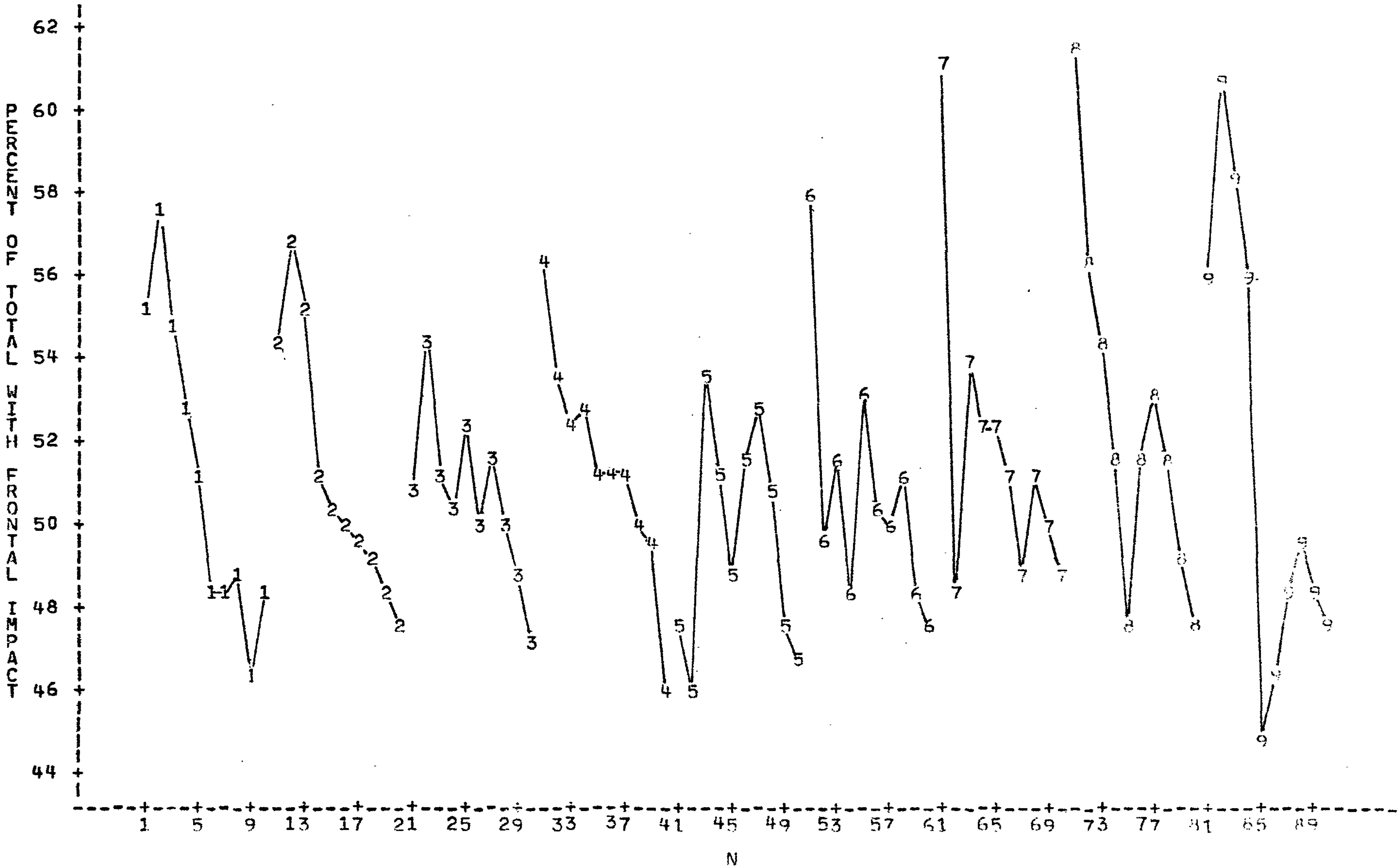
A complete listing of this data is given in Appendix B.

Initial analyses of these variables showed very strong (and nearly linear) accident year effects contrary to expectations. Upon reflection, however, it was recognized that since in these analyses the same model year vehicles appear in each accident year, the variables accident year and vehicle age could act together to produce a model year effect. Such a model year effect is apparent from figure 3 which shows the percent of frontal impacts by model year within accident year. The points on the graphs are labelled with the last digit of the accident year, and for each accident year the points correspond, consecutively, to model years 1960 through 1969. To the extent that the accident year graphs tend to increase somewhat from left to right, the figure also shows a slight vehicle age effect. An effect due to the increasing percentage of cars with dual braking systems should be seen primarily as a substantial decrease in the percentage of frontal impacts between 1965 and 1967 model year cars. Such an effect does not appear to be present in the data of figure 3.

The percentage of cars with power brakes, however, decreases from 1960 to 1961, and then increases steadily through 1968, with a larger increase from 1968

PERCENT FRONT
BY
MODEL YEAR WITHIN ACCIDENT YEAR

Figure 3



to 1969 (see Table 2). Thus, the power brakes variable is strongly associated with vehicle model year. It would not be expected, however, that the effect of this variable (power brakes) would result in such a substantial change in braking performance as is seen in Figure 3.

In an attempt to suppress a pure model year effect a regression model was run using as independent variables accident year (in three categories corresponding to changes in reportin forms at the end of 1972 and 1978), vehicle age, the percentage of cars with dual brakes, and the percentage with power brakes. The results of this model are shown in Table 13. In this model most of the model year effect has been attributed to power brakes, as can be seen by the large netative regression coefficient. With accident year removed from the model

Table 13. Model for early model front-to-rear crashes with accident year classes.

Source	D.F.	Sum of Squares	F-Value	P
Accident year	2	12.00	4.50	.0143
Age	1	17.45	13.08	.0005
Dual Brakes	1	4.98	3.73	.0572
Disc Brakes	1	13.98	10.48	.0018

Parameter	Estimate
Intercept	49.052
Class 1 (71-72)	3.644
Class 2 (73-78)	2.313
Age	0.444
Dual Brake	0.017
Power Brake	-0.181

$R^2 = .644$

the power brake effect becomes even stronger as can be seen from Table 14. In both of these models the effect attributed to power brakes seems much too large to represent a real effect with respect to braking performance due to an increasing percentage of cars equipped with power brakes.

Table 14. Model for early model front-to-rear crashes with accident year omitted.

Source	D.F.	Sum of Squares	F-Value	P
Age	1	6.281	4.32	.0411
Dual Brakes	1	3.677	2.53	.1160
Power Brakes	1	35.636	24.49	.0001

Parameter	Estimate
Intercept	57.32
Age	0.149
Dual Brakes	0.014
Power Brakes	-0.255

$R^2 = .601$

Table 15. Model year effect in early model front-to-rear crashes.

Source	D.F.	Sum of Squares	F-Value	P
Vehicle Age	1	3.48	2.73	.1019
Vehicle Model Year	1	92.36	72.44	.0001

Parameter	Estimate
Intercept	53.25
Age	0.105
Model Year	-0.701

$R^2 = .632$

For purposes of comparison models were run with the brake related variables replaced by a model year variable (i.e., the sequence of last digits 0-9). Table 15 shows the results of such a model where it can be seen that model year has a very strong effect and even vehicle age is no longer statistically significant. Finally, Table 16 shows the results of a model containing only the model year variable. This model certainly confirms the fact that the data on the percentage of early model year cars that are the striking vehicle in two car front-to-rear crashes, contains a large component which seems to be model year related. Some portion of this component may be due to changes in braking

Table 16. Early model front-to-rear crashes as a function of model year only.

Source	D.F.	Sum of Squares	F-Value	P
Vehicle Model Year	1	186.74	143.62	.0001

Parameter	Estimate	
Intercept	53.25	
Model Year	-0.784	R^2 = .601

systems that occurred over these model years. It seems quite unlikely, however, that effects of the magnitudes of those attributed to power brakes in Tables 13 and 14, can, in fact, really be entirely due to the increasing percentage of cars having power brakes, and not to some other unknown model year related phenomenon.

Analysis of FMVSS 105-75

As the work reported on in the previous sections was nearing completion, the Contract Technical Manager subsequently requested HSRC to study the effects, if any, of additional braking improvements made on certain cars in response to Federal Motor Vehicle Safety Standard 105-75 (effective January 1976). These improvements may have consisted of using improved brake lining materials, including proportioning and metering values to prevent brake imbalance, or, in a few cases, using larger rear drums. The improvements were in most cases made by model year 1976, though in some cases by 1975. These improvements may also have contributed to the reduction of brake failure crashes and front-to-rear impacts. In fact, it is possible that some of the effects in the preceding sections attributed to disc brakes may have, in part, been due to these improvements.

In order to investigate the effects of FMVSS 105-75, a new variable (Std. 105-75) was defined as follows:

$$\text{Std. 105-75} = \begin{cases} 0 \text{ if model year} \leq 1974 \\ \text{unknown if model year} = 1975 \\ 100 \text{ if model year} \geq 1976. \end{cases}$$

This variable was then inserted into the regression models of the preceding sections with the exception of those pertaining to the earlier model cars. The results for the brake defect models are given in Tables 17, 18, and 19 below.

Table 17. Brake defects relative to Std. 105-75 in all accidents.

Source	DF	Sum of Squares	F-Value	P
Accident Year	3	163.28	27.20	.0001
(Age)	1	513.24	256.46	.0001
Vehicle Weight (pounds)	1	5.23	2.61	.1084
Dual Brakes (percent)	1	167.63	83.77	.0001
Disc Brakes (percent)	1	142.47	71.19	.0001
Std. 105-75 (percent)	1	0.45	0.22	.6373

Parameter		Estimate
Intercept		2.603
Acc. Yr.	71	-0.616
	72	-0.483
	73-78	-0.355
$(Age)^2$		0.010
Vehicle Weight		-0.0002
Dual Brakes		-0.007
Disc Brakes		-0.006
Std. 105-75		0.0002

$R^2 = .957$

Table 18. Brake defects relative to Std. 105-75 in hilly region accidents.

Source	DF	Sum of Squares	F-Value	P
Accident Year	2	23.77	10.22	.0001
$(Age)^2$	1	70.59	60.70	.0001
Dual Brakes (percent)	1	42.92	36.90	.0001
Disc Brakes (percent)	1	24.89	21.40	.0001
Std. 105-75 (percent)	1	0.000	0.00	.9948

Parameter		Estimate	
Intercept		2.105	
Acc. Yr.	71	-0.598	R^2 = .826
	72-78	-0.394	
$(Age)^2$		0.009	
Dual Brakes		-0.009	
Disc Brakes		-0.006	
Std. 105-75		-5.04×10^{-6}	

Table 19. Brake defects relative to Std. 105-75 in wet weather accidents.

Source	DF	Sum of Squares	F-Value	P
Accident Year	2	43.25	9.40	.0002
Age	1	61.24	26.64	.0001
$(Age)^2$	1	19.37	8.43	.0043
Dual Brakes (percent)	1	12.67	5.51	.0204
Disc Brakes (percent)	1	39.97	17.39	.0001
Std. 105-75 (percent)	1	0.15	0.07	.7956

Parameter		Estimate	
Intercept		1.228	
Acc. Yr.	71	-0.604	R^2 = .706
	72-78	-0.328	
Age		0.129	
$(Age)^2$		-0.005	
Dual Brakes		-0.003	
Disc Brakes		-0.006	
Std. 105-75		0.0002	

These tables clearly show Std. 105-75 to have had virtually no effect with respect to brake defect incidence in any of the three accident conditions.

In the same way the Std. 105-75 variable was also incuded in the regression models for the more recent model year cars in front-to-rear crashes. The results of these analyses are shown in Tables 20, 21, and 22. For hilly region accidents and wet weather accidents the Std. 105-75 variable was again nonsignificant. In the all accident situation, however, it is statistically significant and has a positive paramater estimate (i.e., the percentage of cars with frontal impacts tended to increase after the 1975-1976 braking improvements were implemented). To examine this further, the effects of Std. 105-75 were estimated within each car class. It was found that in only three of the twenty

Table 20. Effect of Std. 105-75 in all front-to-rear accidents.

Source	DF	Sum of Squares	F-Value	P
Class	19	562.84	20.39	.0001
Age	1	34.74	23.91	.0001
$(Age)^2$	1	28.81	19.83	.0001
Disc Brakes (percent)	1	2.30	1.58	.2086
Power Brakes (percent)	1	1.58	1.09	.2976
Std. 105-75 (percent)	1	5.85	4.03	.0450

Parameter*	Estimate	
Intercept	50.060	
Age	-1.036	R^2 = .283
$(Age)^2$	0.076	
Disc Brakes	-0.010	
Power Brakes	0.011	
Std. 105-75	1.189	

*The 19 car class parameters are not included.

Table 21. Effect of Std. 105-75 in hilly region front-to-rear accidents.

Source	DF	Sum of Squares	F-Value	P
Class	18	36.14	1.58	.0617
Age	1	1.51	1.19	.2757
$(Age)^2$	1	1.05	0.83	.3634
Disc Brakes (percent)	1	0.14	0.11	.7384
Power Brakes (percent)	1	1.48	1.17	.2803
Std. 105-75 (percent)	1	2.98	2.35	.1264

Parameter*	Estimate	
Intercept	56.624	
Age	-0.971	$R^2 = .089$
$(Age)^2$	0.065	
Disc Brakes	0.011	
Power Brakes	-0.049	
Std. 105-75	-6.377	

*Individual class parameters are omitted.

Table 22. Effect of Std. 105-75 in wet weather front-to-rear accidents.

Source	DF	Sum of Squares	F-Value	P
Class	19	77.19	3.49	.0001
Age	1	12.43	10.69	.0011
$(Age)^2$	1	10.04	8.63	.0034
Disc Brakes (percent)	1	0.09	0.08	.7773
Power Brakes (percent)	1	5.17	4.44	.0353
Std. 105-75 (percent)	1	1.44	1.24	.2660

Parameter*	Estimate	
Intercept	55.401	
Age	-1.480	$R^2 = .135$
$(Age)^2$	0.110	
Disc Brakes	0.004	
Power Brakes	-0.048	
Std. 105-75	1.569	

*Individual class parameters not included.

car classes was the Std. 105-75 variable significant. The results for these classes are shown in Table 23. When the three car classes in Table 23 were

Table 23. Effect of Std. 105-75 by car class.

Car Class	Coefficient for Std. 105-75	P
8	4.88	.0467
12	8.07	.0006
16	9.77	.0008

omitted from the "all accident" regression the Std. 105-75 variable was no longer statistically significant (F = 1.12, P = .3335). By looking back at Table 8 it may be noticed that composition of each of the car classes of Table 23 differed over the two time intervals defined by the values of Std. 105-75 (i.e., 0% through 1974, and 100% from the 1976 onward). This is most noticable in Class 16 which is basically Fury and Polara through 1973, then Fury and Monaco in 1974. In 76 and 77 it becomes Gran Fury, Royal Monoco, and Chrysler/Cordoba. Class 8 is basically Nova and Ventura through 1973, Omega and Apollo were added in 1974, Apollo dropped out in 1976, and the class becomes Nova/citation and Phoenix in 1978 and 1979. Class 12 consisted of the Pinto only from 1972 through 1976, then Bobcat was added in 1977. The Pinto itself, however, became heavier and increased in engine size between 1974 and 1976. It would seem, then, that the regression effects attributed to Std. 105-75 may, more likely, be due to changes in car class composition.

In any case, we see no evidence of a reduction in the percentage of cars with frontal damage in two car front-to-rear crashes as a result of the brake improvements of 1975 and 1976.

REFERENCES

Freund, R. J. and Little, R. C. (1981). SAS for Linear Models. Cary, N.C. SAS Institute, Inc.

APPENDIX A: COMPUTER PROGRAMMING DOCUMENTATION

Prepared by

Douglas Easterling

Task 1 - Analysis of Defective Brake Incidence

Tables were constructed which indicate the percentage of cars with a given model year which were reported to have defective brakes. For each accident year 1971 to 1979, data were presented for model years 1960 through the accident year plus one (e.g., for accident year 1974, there were 1975 model year cars involved in accidents). All vehicles included were domestic passenger cars involved in reported accidents in the state of North Carolina.

The brake defect totals are stored on disk in the SAS data base "UNC.HSR.F205Q.DVE.DWR.#SAS.BRAKEDEF.TABLES." There are three SAS data sets in this file, 1) ALLACCYR, 2) HLYACCYR, and 3) WETACCYR, which correspond respectively to 1) all accidents, 2) accidents occurring in hilly counties, and 3) accidents occurring under wet road conditions. For each file, observations consist of the following variables:

1) ACCYEAR - accident year
2) MODYEAR - model year
3) AGE - vehicle age defined as (ACCYEAR + 1) - MODYEAR
4) WTMEAN - mean weight for the model year, calculated only within the given accident year
5) BASEDONN - the number of vehicles upon which the mean weight is based
6) NUMBRAKS - the number of vehicles with reported brake defects
7) PERCENTB - the percentage of total cars of the given model year in the given accident year with defective brakes
8) NUMOTHER - the number of vehicles with either no reported defect or a defect other than brakes
9) PERCENTO - the percentage of the total with other or no defects
10) TOTAL - total number of vehicles with the given model year having accidents in the given accident year (NUMBRAKS + NUMOTHER)

11) DUALBRAK - the percentage of the model year fleet having dual master cylinders (unknown for model year 1966)

12) DISCBRAK - the percentage of the model year fleet having disc brakes

13) POWRBRAK - the percentage of model year fleet having power brakes

The data sets are sorted by accident year. Each data set has 153 observations, i.e., 153 accident year/model year combinations.

The programming sequence which produced the tables will be described below. All processing was performed using SAS.

STEP 1

- SELECT DOMESTIC PASSENGER CARS

North Carolina accident data files for accident years 1971-1979 were passed. Each vehicle was tested to determine whether it was a passenger car and whether the make was domestic. Based on the Polk-supplied VIN type, cars were selected if the VIN was unclassified (0) or the VIN was classified as a passenger car (1). If the VIN was unclassified by Polk, the vehicle was tested for type using the vehicle type reported by the officer. If the officer classified the vehicle as a passenger car (1), the car was selected.

Considering only passenger cars, tests were made of domestic vs. foreign ("foreign" here included, among others, Dodge and Plymouth imports, Capris up through 1978, and all Volkswagens). Tests of make were based on three criteria of decreasing reliability or comprehensiveness: 1) Polk-supplied HSR Type, 2) Vehicle Make provided by the HSRC program, and 3) the officer's reported vehicle make. Cars were selected if 1) the Polk HSR Type was domestic (0), 2) the Polk HSR Type was unclassified (9) and the HSRC Vehicle Make was one of 13 domestic varieties (1-13), or 3) the Polk HSR Type was unclassified (9), the HSRC Vehicle Make was either unclassified (99) or unknown because of vehicle age (97), and the officer's reported make matched one of the strings representing a possible spelling of a domestic vehicle make. One exception to this processing was for accident year 1979 where HSRC Vehicle Makes were not available.

The items of the accident report corresponding to the variables are as follows:

Variable	Item Number 1971-1972	1973-1978	1979
VIN Type	77	110	99
Officer's Vehicle Type	45	30	44
Polk HSR Type	79	54A	84
HSRC Vehicle Make	68d	114	NA
Officer's Vehicle Make	65	48	43

The program files and the data files they created are listed below. Each data file consists of raw records which are identical to those in the N.C. accident file which was passed.

PROGRAM FILE	DATA FILE CREATED
UNC.HSR.F2050.EASTERLI.FNDDOM12	UNC.HSR.F2050.DVE.DWR.#144X.ACC7172,DOM UNIT=TAPE,VOL=SER=USS220 DCB=(BLKSIZE=31824,LRECL=221,RECFM=FB) 347,142 OBSERVATIONS (77.67 of all cars involved in 71-72 accidents)
UNC.HSR.F2050.EASTERLI.FNDDOM34	UNC.HSR.F2050.DVE.DWR.#355X.ACC7374.DOM UNIT=TAPE,VOL=SER=USS163 DCB=(BLKSIZE=31824,LRECL=261,RECFM=FB) 351,155 OBSERVATIONS (68.5%)
UNC.HSR.F2050.EASTERLI.FNDDOM56	UNC.HSR.F2050.DVE.DWR.#355X.ACC7576.DOM UNIT=TAPE,VOL=SER=USS180 DCB=(BLKSIZE=31824,LRECL=261,RECFM=FB) 345,815 OBSERVATIONS (62.6%)
UNC.HSR.F2050.EASTERLI.FNDDOM78	UNC.HSR.F2050.DVE.DWR.#355X.ACC7778.DOM UNIT=TAPE,VOL=SER=USS181 DCB=(BLKSIZE=31824,LRECL=261,RECFM=FB) 366,920 OBSERVATIONS (58.3%)
UNC.HSR.F2050.EASTERLI.FNDDOM9	UNC.HSR.F2050.DVE.DWR.#382.ACC79.DOMCAR UNIT=TAPE,VOL=SER=USS153 DCB=(BLKSIZE=31929,RECFM=FB,LRECL=307) 189,528 OBSERVATIONS (59.3%)

STEP 2

- CREATE ACCIDENT FILES WITH APPROPRIATE VARIABLES

To tabulate the appropriate summary statistics, individual accident records were processed so that each car involved had values on relevant variables. These included vehicle weight, model year, accident year, and vehicle defect. Vehicle weight was supplied by the Polk package when available (post-65 model years) and by the HSRC VIN-classification package when the Polk package failed. A number of cars could still not be assigned a weight due to unrecorded VINs, etc. Model years for cars followed the same schedule of 1) Polk-supplied model year, if available, 2) failing that, HSRC-supplied model year, if available, and finally 3) failing that, the officer-supplied model year. Accident year came directly from the accident record. Vehicle defect was scored as either 1) brake (if the item was marked "brakes"), 2) other (for either some other defect marked or no defect marked), or 3) unknown (for either "not stated" or "not known if defective"). Only those cars with model years of 1960 and later, and with defects of either brakes or other were retained for analysis.

The items on the accident report which correspond to the above variables are as follows:

	Item Number		
Variable	1971-1972	1973-1978	1979
Accident Year	1	1	1
Officer's Model Year	66	49	42
HSRC Model Year	68g	54d	NA
Polk Model Year	84	117	89
Vehicle Defect	49	36	69
HSRC Weight	68i	55	NA
Polk Weight	86	119	91

Step 2 was one phase of the following programs:

UNC.HSR.F2050.EASTERLI.BRKTBL.ACC7172
UNC.HSR.F2050.EASTERLI.BRKTBL.ACC7378
UNC.HSR.F2050.EASTERLI.BRKTBL.ACC79

STEP 3

- CREATE FILES WITH SUMMARY STATISTICS FOR ALL ACCIDENTS

Proc Summary was used to obtain both frequency counts and mean weights for each model year/accident year combination. Proc Summary was performed with class variables of accident year, model year and vehicle defect. In this way, a mean weight was calculated for each accident year/model year combination, and frequencies were calculated for number of vehicles in each accident year/model year with brake defects and with other defects (the mean weight figures were collapsed across brake defects).

Using the _TYPE_ variable generated by Proc Summary, two data sets were created. Data set WEIGHT had one observation per accident year/model year giving the mean weight. Data FREQ had two observations per accident year/model year, the first with the number of cars with brake defects and the second with the number of cars with other defects.

In order to consolidate both sets of information into one data set, WEIGHT and FREQ were merged together by a dummy variable ACCMODYR. This variable simply took the accident year as its first four digits and the model year as its last four digits. The resultant data set thus had two observations per accident year/model year, each with the mean weight variable, one with "brake" frequency and the other with "other" frequency.

To consolidate again, this data set was first divided into the data sets BRAKE and OTHER where each contained observations with the respective frequency counts. Again these two data sets were merged together by ACCMODYR so that each accident year/model year had frequency counts for brake defects and for other defects, as well as having the mean weight for the entire category.

The age, percentage and total variables were constructed using simple arithmetic. Other pertinent information regarding percentages of model year fleets with disk brakes, power brakes and dual master cylinders were extracted from other sources and merged with the summary tables.

The following programs performed this processing in order:

UNC.HSR.F2050.EASTERLI.BRKTBL.ACC7172
UNC.HSR.F2050.EASTERLI.BRKTBL.ACC7378
UNC.HSR.F2050.EASTERLI.BRKTBL.ACC79
UNC.HSR.F2050.EASTERLI.FIXTBLES.BRAKES
UNC.HSR.F2050.EASTERLI.MERGE.BRKSTATS.TSK1

STEP 4

- PERFORM PARALLEL PROCEDURES FOR HILLY COUNTIES AND WET ROAD CONDITIONS

Corresponding tables were constructed for 1) accidents occurring in hilly counties and 2) accidents occurring under wet road conditions. When accident records were processed for model year and vehicle weight in Step 2, records were also checked to see in which county the accident occurred, the road condition and the weather condition. If the accident occurred in the mountainous sections of North Carolina (county = Alleghany, Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Graham, Haywood, Henderson, Jackson, Mason, Madison, McDowell, Mitchell, Polk, Rutherford, Surrey, Swain, Transylvania, Watauga, Wilkes, or Yancey), the vehicle was included in the hilly county summary.

Vehicles were included in the wet road condition category if 1) the road condition was wet, muddy, oily, snowy or icy, or 2) the weather was rain, snow, sleet or hail.

Exactly the same steps were followed in setting up these tables as were for the entire state case. The variables used to classify accidents correspond to the following items:

	Item Number		
Variable	1971-1972	1973-1978	1979
County	18	10	14
Road Condition	23	17	33
Weather Condition	27	19	35

The following programs were used, in order, to set up the tables:

UNC.HSR.F2050.EASTERLI.BRKTBL.HLWT7172
UNC.HSR.F2050.EASTERLI.BRKTBL.HLWT7378
UNC.HSR.F2050.EASTERLI.BRKTBL.HLWT79
UNC.HSR.F2050.EASTERLI.FIXTBLES.BRAKES
UNC.HSR.F2050.EASTERLI.MERGE.BRKSTATS.TSK1

Task 2a. Analysis of Two-Car Front-Rear Collisions Where Cars are Classified According to HSR Groups

Tables of results for this task indicate the percentage of cars within a given car line sustaining frontal damage and the percentage sustaining rear damage in front-to-rear collisions. All domestic passenger cars with model years 1967 and later which were involved in such accidents were categorized by accident year, model year and HSR Group. Summary statistics were then given for each accident year/model year/HSR Group combination with the percentage of the group having a frontal initial impact region to serve as the dependent measure. Records were used for North Carolina accidents occurring between 1971 and 1979.

These front-rear collision data are stored on disk in the SAS data base "UNC.HSR.F2050.DVE.DWR.#SAS.FTRRHSR.ALLTABLE" in the SAS data set ALL7179. Similar tables appear for accidents in hilly counties (DSN=UNC.HSR.F2050.DVE.DWR.#SAS.FTRRHSR.HILTABLE, SAS data set = HILY7179) and for accidents occurring under wet road conditions (DSN=UNC.HSR.F2050.DVE.DWR.#SAS.FTRRHSR.WETTABLE, SAS data set = WET7179). For each of the three files, observations consist of the following:

1) ACCYEAR - accident year

2) MODYEAR - model year

3) HSRGRP - HSR Car Group (corresponds to the Polk car line variable) (These HSR Group numbers are formatted according to model year in the SAS library, "UNC.HSR.F2050.DVE.DWR.#SAS.HSRGRP.FORMATS." There are 13 formats, corresponding to each model year from 1967 through 1979. Format names have the form HSRxxMOD where xx is the model year, e.g., HSR71MOD. for model year 1971. These formats were created by the program "UNC.HSR.F2050.EASTERLI.HSRFORMT.")

4) WTMEAN - mean weight for the particular HSR group of the given model year within the given accident year (WTMEAN may differ across accident years for the same model year/HSR group combination).

5) BASEDONN - the number of vehicles upon which the mean weight is based (always less than or equal to TOTAL).

6) NUMFRONT - the number of cars with the given accident year/model year/HSR group combination which suffered frontal damage in front rear collisions.

7) PERCENTF - (NUMFRONT/TOTAL) x 100

8) NUMREAR - the number of cars with the given accident year/model year/HSR group combination which suffered rear damage in front-rear collisions.

9) PERCENTR - (NUMREAR/TOTAL) x 100

10) TOTAL - total number of cars with the given accident year/model year/HSR group combination which were involved in front-rear collisions (NUMFRONT - NUMREAR).

The data sets are sorted by accident year. ALL7179 has 3867 observations, i.e., accident year/model year/HSR group combinations. HILLY7179 has 2848 observations and WET7179 has 3312 observations.

These tables were produced by the following sequence of steps. Tables for hilly counties were constructed by selecting out accidents occurring in the 24 mountainous counties of North Carolina (see Step 4 of Task 1). Tables for wet road conditions were formed after selecting out those accidents occurring when the road condition was wet, icy, snowy, oily or muddy, or when the weather condition was rain, snow, sleet or hail. (See Task 1, Step 4 for item number for these three variables.)

STEP 1

- SELECT DOMESTIC PASSENGER CARS

See Step 1 of Task 1. The same files created there were used in Task 2a.

STEP 2

- SELECT ALL DOMESTIC CARS INVOLVED IN FRONT-TO-REAR COLLISIONS

Using the files of domestic passenger cars to draw from, selection was made of both cars involved in front-to-rear collision. Because the limited file was used to start with, only collisions in wich both vehicles could be recognized as domestic passenger cars were included in the front-rear files.

Records were first tested to see if the accident was a two-car collision (for accident years 1971-1978, this corresponded to the variable "accident type"; for accident year 1979, the less informative variable "units involved" was used). For these cases, a test was made to see if the first vehicle encountered actually had a vehicle position of 1. If not, this meant that Vehicle No. 1 was not in the file (not a domestic passenger car), and consequently the vehicle at hand was discarded. When a car was found to be the first vehicle of a two-car accident, it was then checked to see if its initial region of impact was either the front or the rear. (For 1971 and 1972 accidents, points of contact 1, 2, and 8 were considered front and points 4, 5, and 6 were considered rear. For 1973 through 1978 accident years, points of contact 1, 2, 3, 4, 21, and 25 were considered front and points 8, 14, 15, 16, 17, and 27 were considered rear. For accident year 1979, contact points 1, 2, 3, 4, and 21 were considered front, while points 8, 14, 15, 16, and 17 were considered rear.)

For cars with either front or rear impact regions, the entire raw record was retained as a character string, along with the case number and the impact region. In the same data step, the next record was then input in order to further test the type of accident. If the case number of the next car was the same as that retained for the first car, then both cars were involved in the same accident (this test would fall out if Vehicle 2 of the accident was a truck and thus was missing from the file). If the case numbers of the two cars did differ, the first car was discarded (its accident did not involve two domestic cars) and the second car was sent back to the beginning of the data step to be tested if it was involved in a two-car collision. The only time a data record was written was when one car was classified as Vehicle 1 of a two-car collision and the next car tested had the same case number and was classified as Vehicle

2. Additionally, either Vehicle 1 must have a rear impact region and Vehicle 2 must have a frontal impact region or vice versa.

Whenever a pair of cars involved in a two-car front-to-rear collision was found, the entire raw records of each were written to a data file. In addition to the raw record, the model year and HSR group of the other car were attached to the end, occupying 2 bytes and 3 bytes, respectively.

The accident file items corresponding to the selection variables are as follows:

	Item Number		
Variable	1971-1972	1973-1978	1979
Case Number	2	2	2
Impact Region	53	106	32
Vehicle Position	44	3	2A
Accident Type (Units Involved)	3	105	13
HSR Group	82	115	87
Polk Model Year	84	117	89
HSRC Model Year	68g	54D	NA
Officer's Model Year	66	49	42

The two-car collision data files and the programs which created them are given below:

PROGRAM	DATA FILE
UNC.HSR.F2050.EASTERLI.FNDTWO12	UNC.HSR.F2050.DVE.DWR.#144X.ACC7172.TWCARCOL UNIT=TAPE,VOL=SER=UTS268,LABEL=2 DCB=(BLKSIZE=31866,RECFM=FB,LRECL=312) 94,426 OBSERVATIONS (27.2% of Total of ACC7172.Domestic File)
UNC.HSR.F2050.EASTERLI.FNDTWO38	UNC.HSR.F2050.DVE.DWR.#355X.ACC7378.TWCARCOL UNIT=TAPE,VOL=SER=UTS413 DCB=(BLKSIZE=31920,RECFM=FB,LRECL=266) 163,084 OBSERVATIONS (15.3% of All Domestic Cars)
UNC.HSR.F2050.EASTERLI.FNDTWO9	UNC.HSR.F2050.DVE.DWR.#382T.ACC79.TWCARCOL UNIT=TAPE,VOL=SER=UTS268,LABEL=1 DCB=(BLKSIZE=31824,RECFM=FB,LRECL=312) 27,534 OBSERVATIONS (14.5% of All Domestic Cars)

STEP 3

- CREATE SAS DATA SET WITH ALL HSR-CLASSIFIED, POST-66 FRONT-REAR CARS

In this step, appropriate cars were selected and records were transformed from raw form to SAS observations. For each accident year, cars were selected if their model years were 1967 or later, and if there was a Polk-supplied HSR Group number, i.e., if the VIN was decodable. Cars were selected from the files created in Step 2. While both cars in the accident had to be domestic to be included in those files, there was no further restriction in this step for both cars to be post-66 with non-missing HSR groups. If either car of the accident satisfied the requirements, it was included, regardless of the status of the other car.

Cars were selected if the Polk-supplied model year was 1967 or above and if the Polk-supplied car line (HSR Group) was between 0 and 100, exclusive. A car line of 0 represented unclassified while anything over 100 indicated something other than a domestic car (these should not be in the file anyway). SAS variables were created for vehicle weight, model year, accident year, impact region (character, either "front" or "rear"), and HSR group, among others not used in analysis. These variables correspond to items in the accident files as follows:

	Item Number		
Variable	1971-1972	1973-1978	1979
ACCYEAR	1	1	1
MODYEAR (Polk-supplied)	84	117	39
WEIGHT (Polk-supplied)	86	119	91
HSRGRP	82	115	87
IMPREG	53	106	82

The SAS data set is called OBS7179 and is a member of the SAS data base "UNC.HSR.F2050.DVE.DWR.#SAS.FTRRCOL.HSR6779." (UNIT=TAPE,VOL=SER=UTS418,LABEL=1, DCB=(BLKSIZE=32760,LRECL=32756,RECFM=U)). It was created by the program file "UNC.HSR.F2050.EASTERLI.TWCARCOL.HSR6779."

STEP 4

- CREATE TABLES FOR FRONT AND REAR IMPACT REGIONS BY ACCIDENT YEAR/MODEL YEAR/HSR GROUP

Proc Summary was used to obtain both frequency counts and mean weights for each accident year/model year/HSRC group combination. Proc Summary was performed with class variables of accident year, model year, HSR group and impact region. In this way, a mean weight was calculated for each accident year/model year/HSR group combination, and frequencies were calculated for number of vehicles in each category with frontal impact regions and for number of vehicles with rear impact regions (the mean weight figures were collapsed across impact regions).

Using the _TYPE_ variable generated by Proc Summary, two data sets were created. Data set WEIGHT had one observation per category giving the mean weight. Data FREQ had two observations per category, the first with the number of cars of the given accident year/model year/HSR group category with frontal impact regions and the second with the number of cars in that same category with rear impact regions.

In order to consolidate both sets of information into one data set, WEIGHT and FREQ were merged together by a dummy variable ACMODHSR. This variable simply took the accident year as its first 4 digits, the model year as its next 4 digits and the HSR group number as its last 3 digits. (Merge only operates with one by-variable). The resultant data set had two observations per category, each with the mean weight variable, one with "front" frequency and the other with "rear" frequency.

To consolidate again, this data set was first divided into the data sets FRONT and REAR where each contained observations with the respective frequency counts. Again these two data sets were merged together by ACMODHSR so that each accident year/model year/HSR group combination had frequency counts for frontal impact and rear impact, as well as having the mean weight for the entire category.

The percentage and total variables were then calculated using simple arithmetic.

The following programs generated the final three sets of tables:

"UNC.HSR.F2050.EASTERLI.FTRRHSR.ALLTABLE"
"UNC.HSR.F2050.EASTERLI.FTRRHSR.HILTABLE"
"UNC.HSR.F2050.EASTERLI.FTRRHSR.WETTABLE"

Task 2b. Analysis of Two-Car Front-Rear Collisions Where Cars Have Model Years 1960 to 1969

As in Task 2a, tables indicating frontal and rear damage in front-to-rear collisions were constructed. In this case, only cars with model years 1960 to 1969 were considered. Cars were not broken down into HSR groups, but rather were classified only by model year. The same 1971-79 North Carolina accident files used in Task 2a formed the sampling base in this task.

The front-rear collision summaries for this task are stored on disk in the SAS data base "UNC.HSR.F2050.DVE.DWR.#SAS.FTRRCOL.DOM609TB" in the SAS data set ACCYRBRK. Observations in the data set conist of the following variables:

1) ACCYEAR - accident year

2) MODYEAR - model year

3) WTMEAN - mean weight for the model year within the given accident year.

4) BASEDONN - the number of cars upon which the mean weight is based.

5) NUMFRONT - the number of cars with the given accident year/model year combination which suffered frontal damage in front rear collisions

6) PERCENTF - (NUMFRONT/TOTAL) x 100

7) NUMREAR - the number of cars with the given accident year/model combination which suffered rear damage in front-rear collisions.

8) PERCENTR - (NUMREAR/TOTAL) x 100

9) TOTAL - total number of cars with the given accident year/model year combination which were involved in front-rear collisions (NUMFRONT + NUMREAR)

10) AGE - Vehicle age ((ACCYEAR+1)-MODYEAR)

11) POWRBRAK - percentage of model year fleet equipped with power brakes

12) DUALBRAK - percentage of model year fleet equipped with dual master cylinder brakes

The data data is sorted by accident year.

The following steps produced the Task 2b tables:

STEP 1

- SELECT DOMESTIC PASSENGER CARS

See Step 1 of Task 1. The same files created there were used in Task 2b.

STEP 2

- SELECT ALL DOMESTIC CARS INVOLVED IN FRONT-TO-REAR COLLISIONS

See Step 2 of Task 2a. The same files created there were used in Task 2b.

STEP 3

- CREATE SAS DATA SET WITH ALL FRONT-REAR CARS WITH MODEL YEARS 60-69.

In this step, appropriate cars were selected and records were transformed from raw form to SAS observations. For each accident year, cars were selected from the front-rear files of Step 2 if they had model years of 1960 to 1969. There was no requirement that both cars involved in the collision have model years 60-69 for one to be selected. Model year was determined based on an established hierarchy of variables. If the Polk-supplied model year was available, it was relied on as the most reliable source. The next variable used was the HSRC-supplied model year. This was especially important here since Polk only classifies post-1965 model year cars. If neither package-supplied model was available (VIN not decodable), the officer's reported model year was utilized.

SAS variables were created for vehicle weight, model year, accident year and impact region (character, either "front" or "rear"). Vehicle weight was based on the Polk-supplied vehicle weight when available. Otherwise the HSRC-supplied weight was used. A number of cars were assigned missing values as the VIN was not decodable by either. For accident year 1979, the HSRC package was not run on the data so that only cars with model years 1966-1969 have non-missing vehicle weights.

The variables used in this task correspond to the following items:

Variable	Item Number 1971-1972	1973-1978	1979
ACCYEAR	1	1	1
IMPREG	53	106	82
Officer-Supplied Model Year	66	49	42
HSRC-Supplied Model Year	68g	54d	NA
Polk-Supplied Model Year	84	117	89
HSRC-Supplied Weight	68i	55	NA
Polk-Supplied Weight	86	119	91

The SAS data set is called OBS7179 and is the only member of the SAS data base "UNC.HSR.F2050.DVE.DWR.#SAS.FTRR7179.DOM6069" (UNIT=TAPE,VOL=SER=UTS636, LABEL=1,DCB=(BLKSIZE=32760,LRECL=32756,RECFM=U)). It was created by the program file "UNC.HSR.F2050.EASTERLI.TWCARCOL.DOM6069."

STEP 4

- CREATE TABLE FOR FRONT AND REAR IMPACT REGIONS BY ACCIDENT YEAR/MODEL YEAR

In a manner which parallels Step 4 and Task 2a, tables were formed using Proc Summary. The only exceptions are that only accident year, model year and impact region were used as class variables and the dummy variable used for the various merges was ACCMODYR, a composite of accident year and model year.

Once the tables were formed, data concerning percentage of model year fleet with dual master cylinder brakes and percentage of model year fleet with power brakes were added. These figures were extracted from other sources and were merged with the summary tables.

This processing was performed by these final two programs:

"UNC.HSR.F2050.EASTERLI.FTRR6069.TABLES"
"UNC.HSR.F2050.EASTERLI.MERGE.BRKSTATS.TSK2B"

Table B1

BRAKE DEFECT DATA
ALL ACCIDENTS

ACCIDENT YEAR=1971

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
1	12	1960	3621.0	141	4.372	3225
2	11	1961	3420.0	118	3.091	3817
3	10	1962	3387.0	200	2.825	7080
4	9	1963	3396.5	207	2.142	9663
5	8	1964	3411.5	187	1.594	11730
6	7	1965	3377.4	244	1.682	14505
7	6	1966	3310.9	204	1.330	15334
8	5	1967	3342.7	110	0.790	13928
9	4	1968	3416.7	120	0.746	16086
10	3	1969	3454.0	68	0.396	17187
11	2	1970	3433.8	60	0.378	15857
12	1	1971	3368.1	40	0.357	11196
13	0	1972	3387.1	0	0.000	960

ACCIDENT YEAR=1972

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
14	13	1960	3613.6	65	3.806	1708
15	12	1961	3394.2	105	4.298	2443
16	11	1962	3375.6	158	3.200	4938
17	10	1963	3392.7	169	2.361	7157
18	9	1964	3403.8	175	1.884	9290
19	8	1965	3380.2	247	2.002	12336
20	7	1966	3316.4	227	1.669	13605
21	6	1967	3358.7	139	1.083	12834
22	5	1968	3425.9	117	0.787	14872
23	4	1969	3463.5	117	0.753	15542
24	3	1970	3454.8	60	0.433	13865
25	2	1971	3399.7	64	0.467	13692
26	1	1972	3408.7	45	0.326	13809
27	0	1973	3674.4	3	0.365	822

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
28	14	1960	3662.1	56	4.734	1183
29	13	1961	3409.6	72	4.752	1515
30	12	1962	3351.5	114	3.112	3663
31	11	1963	3369.7	154	2.815	5470
32	10	1964	3393.3	188	2.519	7463
33	9	1965	3388.3	239	2.263	10559
34	8	1966	3311.6	279	2.224	12545
35	7	1967	3351.3	184	1.523	12082
36	6	1968	3425.5	159	1.082	14692
37	5	1969	3468.8	145	0.918	15795
38	4	1970	3477.5	81	0.587	13803
39	3	1971	3422.1	68	0.520	13075
40	2	1972	3439.4	81	0.468	17306
41	1	1973	3530.9	47	0.341	13776

Table B1 (con't)
BRAKE DEFECT DATA
ALL ACCIDENTS

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
42	0	1974	3699.6	0	0.000	607

ACCIDENT YEAR=1974

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
43	15	1960	3601.0	33	4.874	677
44	14	1961	3397.6	40	4.004	999
45	13	1962	3319.2	80	3.281	2438
46	12	1963	3331.2	110	2.922	3764
47	11	1964	3379.6	182	3.339	5451
48	10	1965	3375.7	211	2.588	8152
49	9	1966	3314.6	248	2.402	10324
50	8	1967	3357.2	163	1.582	10301
51	7	1968	3435.1	178	1.379	12912
52	6	1969	3480.0	150	1.061	14132
53	5	1970	3497.7	120	0.962	12471
54	4	1971	3445.8	90	0.774	11633
55	3	1972	3445.8	82	0.561	14615
56	2	1973	3566.1	55	0.342	16093
57	1	1974	3569.6	34	0.360	9452
58	0	1975	3944.4	0	0.000	300

ACCIDENT YEAR=1975

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
59	16	1960	3599.2	22	5.034	437
60	15	1961	3387.7	30	3.911	767
61	14	1962	3320.2	74	4.028	1837
62	13	1963	3324.5	94	3.136	2997
63	12	1964	3371.9	113	2.511	4501
64	11	1965	3361.9	176	2.597	6777
65	10	1966	3305.3	254	2.806	9051
66	9	1967	3358.2	155	1.645	9424
67	8	1968	3427.3	179	1.510	11855
68	7	1969	3491.0	157	1.163	13494
69	6	1970	3495.2	141	1.160	12154
70	5	1971	3437.8	84	0.722	11630
71	4	1972	3480.5	88	0.615	14305
72	3	1973	3592.8	44	0.293	15033
73	2	1974	3569.8	45	0.368	12217
74	1	1975	3747.7	17	0.301	5651
75	0	1976	3769.6	1	0.215	465

Table B1 (con't)

BRAKE DEFECT DATA
ALL ACCIDENTS

------------------------------ ACCIDENT YEAR=1976 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
76	17	1960	3567.4	18	5.014	359
77	16	1961	3383.0	23	4.323	532
78	15	1962	3268.3	49	3.488	1405
79	14	1963	3310.3	88	3.302	2665
80	13	1964	3363.1	129	3.158	4085
81	12	1965	3352.4	186	3.139	5926
82	11	1966	3305.1	233	2.894	8051
83	10	1967	3353.2	160	1.824	8774
84	9	1968	3438.5	215	1.817	11831
85	8	1969	3486.6	162	1.179	13743
86	7	1970	3507.3	149	1.178	12647
87	6	1971	3449.3	104	0.836	12446
88	5	1972	3489.0	99	0.648	15286
89	4	1973	3625.3	78	0.478	16303
90	3	1974	3554.9	41	0.319	12842
91	2	1975	3702.7	25	0.275	9075
92	1	1976	3677.4	31	0.325	9532
93	0	1977	3629.7	2	0.388	515

------------------------------ ACCIDENT YEAR=1977 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
94	18	1960	3667.6	7	2.893	242
95	17	1961	3391.1	16	4.457	359
96	16	1962	3254.6	38	3.725	1020
97	15	1963	3271.1	56	2.859	1959
98	14	1964	3341.4	91	3.021	3012
99	13	1965	3337.5	137	2.920	4691
100	12	1966	3303.4	169	2.646	6387
101	11	1967	3335.8	144	1.974	7295
102	10	1968	3431.7	177	1.737	10192
103	9	1969	3487.1	193	1.585	12176
104	8	1970	3503.9	151	1.230	12272
105	7	1971	3465.7	105	0.871	12062
106	6	1972	3509.3	107	0.716	14954
107	5	1973	3632.9	87	0.538	16183
108	4	1974	3589.1	47	0.370	12713
109	3	1975	3697.8	31	0.342	9076
110	2	1976	3629.5	32	0.247	12949
111	1	1977	3540.0	18	0.186	9665
112	0	1978	3305.0	3	0.647	464

Table B1 (con't)
BRAKE DEFECT DATA
ALL ACCIDENTS

ACCIDENT YEAR=1978

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
113	19	1960	3500.8	13	7.182	181
114	18	1961	3306.4	14	4.575	306
115	17	1962	3233.2	43	5.315	809
116	16	1963	3239.9	38	2.413	1575
117	15	1964	3329.1	91	3.541	2570
118	14	1965	3321.3	126	3.239	3890
119	13	1966	3278.5	171	2.916	5864
120	12	1967	3326.5	148	2.238	6614
121	11	1968	3419.4	172	1.858	9257
122	10	1969	3483.5	221	1.862	11872
123	9	1970	3492.0	171	1.408	12143
124	8	1971	3475.3	135	1.053	12817
125	7	1972	3517.8	154	0.953	16167
126	6	1973	3644.7	116	0.653	17771
127	5	1974	3591.2	71	0.502	14154
128	4	1975	3730.2	39	0.384	10167
129	3	1976	3627.8	51	0.366	13946
130	2	1977	3530.3	35	0.237	14792
131	1	1978	3279.7	35	0.330	10594
132	0	1979	3196.4	1	0.178	561

ACCIDENT YEAR=1979

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
133	20	1960	3500.8	8	5.714	140
134	19	1961	3306.4	11	4.955	222
135	18	1962	3233.2	25	4.072	614
136	17	1963	3239.9	44	3.783	1163
137	16	1964	3329.1	74	3.915	1890
138	15	1965	3321.3	86	2.894	2972
139	14	1966	3246.9	142	3.319	4278
140	13	1967	3308.2	130	2.562	5075
141	12	1968	3406.0	194	2.639	7352
142	11	1969	3473.6	238	2.537	9383
143	10	1970	3496.1	181	1.910	9475
144	9	1971	3469.1	202	1.794	11259
145	8	1972	3531.5	229	1.567	14612
146	7	1973	3662.4	197	1.133	17380
147	6	1974	3585.1	132	0.995	13260
148	5	1975	3706.2	81	0.828	9785
149	4	1976	3625.8	91	0.685	13291
150	3	1977	3536.9	100	0.724	13820
151	2	1978	3274.8	91	0.636	14299
152	1	1979	3121.4	69	0.702	9824
153	0	1980	2736.6	3	0.676	444

Table B2
BRAKE DEFECT DATA
HILLY ACCIDENTS

ACCIDENT YEAR=1971

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
1	12	1960	3597.6	18	4.478	402
2	11	1961	3410.0	12	2.290	524
3	10	1962	3383.9	23	2.349	979
4	9	1963	3351.4	34	2.448	1389
5	8	1964	3384.4	28	1.786	1568
6	7	1965	3329.5	34	1.818	1870
7	6	1966	3263.3	38	1.818	2090
8	5	1967	3298.8	9	0.539	1670
9	4	1968	3368.5	19	0.995	1909
10	3	1969	3416.1	9	0.458	1963
11	2	1970	3397.3	7	0.416	1684
12	1	1971	3343.6	4	0.334	1197
13	0	1972	3461.5	0	0.000	83

ACCIDENT YEAR=1972

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
14	13	1960	3561.5	5	2.283	219
15	12	1961	3488.1	20	6.369	314
16	11	1962	3326.6	22	3.328	661
17	10	1963	3333.2	28	2.875	974
18	9	1964	3381.3	24	1.821	1318
19	8	1965	3342.0	59	3.356	1758
20	7	1966	3257.5	24	1.285	1867
21	6	1967	3310.6	24	1.371	1751
22	5	1968	3381.4	10	0.528	1894
23	4	1969	3408.6	11	0.583	1886
24	3	1970	3397.6	10	0.641	1559
25	2	1971	3339.1	5	0.321	1556
26	1	1972	3382.9	4	0.266	1502
27	0	1973	3636.1	0	0.000	76

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
28	14	1960	3587.3	7	4.192	167
29	13	1961	3420.7	9	4.018	224
30	12	1962	3324.2	24	4.571	525
31	11	1963	3366.4	20	2.649	755
32	10	1964	3372.6	30	2.899	1035
33	9	1965	3336.9	31	2.021	1534
34	8	1966	3261.7	37	2.003	1847
35	7	1967	3286.5	17	0.973	1747
36	6	1968	3384.3	26	1.296	2006
37	5	1969	3389.4	17	0.798	2129
38	4	1970	3416.1	16	0.949	1686
39	3	1971	3379.7	8	0.519	1542
40	2	1972	3417.4	10	0.533	1875
41	1	1973	3473.5	7	0.446	1571

Table B2 (con't)
BRAKE DEFECT DATA
HILLY ACCIDENTS

------------------------------ ACCIDENT YEAR=1973 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
42	0	1974	3359.8	0	0.000	68

------------------------------ ACCIDENT YEAR=1974 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
43	15	1960	3444.0	2	2.198	91
44	14	1961	3263.4	4	2.721	147
45	13	1962	3263.8	12	3.288	365
46	12	1963	3314.0	19	3.565	533
47	11	1964	3343.3	26	3.287	791
48	10	1965	3323.8	25	2.222	1125
49	9	1966	3283.8	38	2.561	1484
50	8	1967	3308.3	32	2.156	1484
51	7	1968	3379.3	19	1.003	1894
52	6	1969	3405.3	13	0.668	1946
53	5	1970	3425.0	11	0.670	1642
54	4	1971	3352.6	13	0.884	1470
55	3	1972	3363.1	9	0.532	1691
56	2	1973	3469.3	5	0.283	1766
57	1	1974	3498.7	5	0.460	1088
58	0	1975	3728.4	0	0.000	30

------------------------------ ACCIDENT YEAR=1975 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
59	16	1960	3572.7	2	3.175	63
60	15	1961	3547.1	3	2.400	125
61	14	1962	3326.4	11	4.183	263
62	13	1963	3325.5	15	3.226	465
63	12	1964	3350.3	20	2.853	701
64	11	1965	3332.6	28	2.697	1038
65	10	1966	3257.3	32	2.242	1427
66	9	1967	3298.7	26	1.840	1413
67	8	1968	3373.1	26	1.499	1734
68	7	1969	3433.7	21	1.141	1841
69	6	1970	3402.5	19	1.156	1644
70	5	1971	3336.5	13	0.862	1508
71	4	1972	3404.5	8	0.456	1756
72	3	1973	3514.6	9	0.523	1721
73	2	1974	3487.6	7	0.503	1393
74	1	1975	3701.0	4	0.641	624
75	0	1976	3710.6	0	0.000	48

Table B2 (con't)
BRAKE DEFECT DATA
HILLY ACCIDENTS

------------------------------ ACCIDENT YEAR=1976 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
76	17	1960	3464.3	2	3.448	58
77	16	1961	3329.3	6	6.522	92
78	15	1962	3343.1	7	3.241	216
79	14	1963	3280.6	14	3.233	433
80	13	1964	3372.1	24	3.834	626
81	12	1965	3312.6	28	3.132	894
82	11	1966	3255.3	32	2.651	1207
83	10	1967	3290.2	26	1.959	1327
84	9	1968	3409.2	38	2.193	1733
85	8	1969	3408.1	21	1.038	2024
86	7	1970	3445.1	22	1.286	1711
87	6	1971	3345.9	11	0.645	1705
88	5	1972	3393.3	10	0.507	1971
89	4	1973	3500.4	8	0.419	1908
90	3	1974	3488.6	5	0.324	1542
91	2	1975	3638.7	3	0.270	1110
92	1	1976	3600.1	5	0.422	1184
93	0	1977	3699.9	1	1.887	53

------------------------------ ACCIDENT YEAR=1977 ------------------------------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
94	18	1960	3654.7	2	4.255	47
95	17	1961	3321.8	4	7.143	56
96	16	1962	3245.1	8	5.161	155
97	15	1963	3263.3	8	2.749	291
98	14	1964	3316.3	20	4.396	455
99	13	1965	3309.8	24	3.463	693
100	12	1966	3292.9	26	2.529	1028
101	11	1967	3277.4	20	1.799	1112
102	10	1968	3372.2	25	1.674	1493
103	9	1969	3428.1	27	1.538	1755
104	8	1970	3422.1	17	0.997	1705
105	7	1971	3342.5	13	0.751	1731
106	6	1972	3440.0	15	0.719	2085
107	5	1973	3535.5	14	0.699	2003
108	4	1974	3478.2	5	0.320	1563
109	3	1975	3581.7	4	0.373	1073
110	2	1976	3523.4	4	0.253	1579
111	1	1977	3468.5	4	0.373	1073
112	0	1978	3395.3	1	1.786	56

Table B2 (con't)
BRAKE DEFECT DATA
HILLY ACCIDENTS

ACCIDENT YEAR=1978

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
113	19	1960	3272.9	1	4.167	24
114	18	1961	3306.3	1	1.961	51
115	17	1962	3181.2	2	2.000	100
116	16	1963	3226.2	5	2.110	237
117	15	1964	3256.9	5	1.330	376
118	14	1965	3263.2	24	4.138	580
119	13	1966	3273.8	23	2.470	931
120	12	1967	3271.4	21	2.104	998
121	11	1968	3370.6	31	2.388	1298
122	10	1969	3424.3	27	1.636	1650
123	9	1970	3418.9	16	0.919	1741
124	8	1971	3375.3	14	0.798	1755
125	7	1972	3405.1	17	0.763	2228
126	6	1973	3521.0	15	0.686	2187
127	5	1974	3432.5	9	0.528	1704
128	4	1975	3624.8	6	0.496	1209
129	3	1976	3544.4	4	0.241	1659
130	2	1977	3456.0	5	0.318	1570
131	1	1978	3232.2	5	0.418	1197
132	0	1979	3192.1	0	0.000	65

ACCIDENT YEAR=1979

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
133	20	1960	3500.8	2	9.524	21
134	19	1961	3306.4	2	7.407	27
135	18	1962	3233.2	1	1.136	88
136	17	1963	3239.9	8	4.040	198
137	16	1964	3329.1	20	6.826	293
138	15	1965	3321.3	11	2.540	433
139	14	1966	3196.5	23	3.522	653
140	13	1967	3254.4	25	3.307	756
141	12	1968	3373.7	26	2.460	1057
142	11	1969	3433.0	30	2.230	1345
143	10	1970	3424.3	24	1.815	1322
144	9	1971	3352.9	30	1.906	1574
145	8	1972	3425.6	43	2.113	2035
146	7	1973	3554.0	23	1.007	2285
147	6	1974	3456.0	21	1.212	1732
148	5	1975	3579.8	12	0.988	1215
149	4	1976	3492.8	12	0.757	1586
150	3	1977	3456.4	7	0.463	1513
151	2	1978	3244.1	8	0.519	1541
152	1	1979	3045.6	12	1.111	1080
153	0	1980	2572.7	0	0.000	44

Table B3
BRAKE DEFECT DATA
WET ACCIDENTS

ACCIDENT YEAR=1971

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
1	12	1960	3589.6	20	2.699	741
2	11	1961	3407.9	34	3.403	999
3	10	1962	3391.7	29	1.547	1875
4	9	1963	3393.3	35	1.328	2635
5	8	1964	3405.9	38	1.215	3127
6	7	1965	3364.8	39	0.979	3983
7	6	1966	3293.4	30	0.723	4150
8	5	1967	3341.0	24	0.645	3723
9	4	1968	3390.2	33	0.740	4458
10	3	1969	3439.6	18	0.380	4731
11	2	1970	3413.7	12	0.279	4299
12	1	1971	3335.6	15	0.522	2873
13	0	1972	3279.8	0	0.000	255

ACCIDENT YEAR=1972

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
14	13	1960	3615.1	9	2.344	384
15	12	1961	3395.3	20	3.584	558
16	11	1962	3340.8	22	1.869	1177
17	10	1963	3384.8	36	2.027	1776
18	9	1964	3406.4	31	1.363	2275
19	8	1965	3360.4	46	1.481	3106
20	7	1966	3304.7	40	1.137	3518
21	6	1967	3362.4	37	1.118	3308
22	5	1968	3422.2	30	0.801	3747
23	4	1969	3459.5	36	0.903	3987
24	3	1970	3421.0	12	0.340	3526
25	2	1971	3372.3	23	0.657	3499
26	1	1972	3385.7	9	0.279	3231
27	0	1973	3640.1	2	0.791	253

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
28	14	1960	3667.1	10	3.802	263
29	13	1961	3400.9	7	2.154	325
30	12	1962	3326.4	30	3.505	856
31	11	1963	3353.2	22	1.727	1274
32	10	1964	3389.2	44	2.423	1816
33	9	1965	3354.6	40	1.587	2520
34	8	1966	3306.8	54	1.721	3138
35	7	1967	3346.6	37	1.310	2824
36	6	1968	3401.1	33	0.929	3551
37	5	1969	3447.2	39	1.033	3774
38	4	1970	3454.8	22	0.641	3433
39	3	1971	3387.6	19	0.617	3078
40	2	1972	3386.8	19	0.446	4264
41	1	1973	3515.1	9	0.327	2756

Table B3 (con't)

BRAKE DEFECT DATA
WET ACCIDENTS

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
42	0	1974	3605.3	0	0.000	142

ACCIDENT YEAR=1974

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
43	15	1960	3598.8	8	5.797	138
44	14	1961	3394.3	6	2.765	217
45	13	1962	3303.0	12	2.065	581
46	12	1963	3309.4	23	2.700	852
47	11	1964	3371.8	37	3.020	1225
48	10	1965	3349.4	24	1.285	1867
49	9	1966	3305.5	36	1.485	2424
50	8	1967	3349.4	38	1.585	2398
51	7	1968	3426.9	33	1.087	3036
52	6	1969	3465.2	28	0.822	3405
53	5	1970	3461.8	31	1.033	3002
54	4	1971	3417.3	25	0.902	2773
55	3	1972	3436.5	28	0.825	3395
56	2	1973	3521.4	13	0.358	3632
57	1	1974	3509.6	10	0.499	2006
58	0	1975	3800.3	0	0.000	69

ACCIDENT YEAR=1975

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
59	16	1960	3643.3	4	4.082	98
60	15	1961	3401.2	10	5.780	173
61	14	1962	3301.4	8	1.843	434
62	13	1963	3315.1	18	2.605	691
63	12	1964	3359.0	18	1.693	1063
64	11	1965	3344.3	29	1.780	1629
65	10	1966	3288.8	51	2.313	2205
66	9	1967	3340.6	30	1.309	2291
67	8	1968	3412.2	31	1.075	2883
68	7	1969	3476.8	33	1.021	3231
69	6	1970	3464.0	26	0.842	3089
70	5	1971	3393.8	17	0.581	2925
71	4	1972	3446.7	29	0.811	3575
72	3	1973	3552.7	13	0.353	3685
73	2	1974	3535.2	12	0.408	2942
74	1	1975	3738.2	7	0.578	1212
75	0	1976	3868.7	0	0.000	117

Table B3 (con't)

BRAKE DEFECT DATA
WET ACCIDENTS

---------- ACCIDENT YEAR=1976 ----------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
76	17	1960	3563.5	0	0.000	64
77	16	1961	3389.0	4	3.670	109
78	15	1962	3269.7	3	1.176	255
79	14	1963	3293.2	19	3.689	515
80	13	1964	3344.8	18	2.187	823
81	12	1965	3366.6	24	1.909	1257
82	11	1966	3297.5	32	1.985	1612
83	10	1967	3354.6	27	1.471	1835
84	9	1968	3417.6	42	1.702	2468
85	8	1969	3463.7	34	1.179	2885
86	7	1970	3479.1	30	1.112	2697
87	6	1971	3407.0	26	0.961	2706
88	5	1972	3469.0	19	0.597	3180
89	4	1973	3588.1	18	0.515	3492
90	3	1974	3525.5	13	0.490	2655
91	2	1975	3684.9	4	0.227	1761
92	1	1976	3642.3	9	0.477	1888
93	0	1977	3617.3	1	0.787	127

---------- ACCIDENT YEAR=1977 ----------

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
94	18	1960	3648.9	1	2.174	46
95	17	1961	3416.3	0	0.000	81
96	16	1962	3191.1	9	3.659	246
97	15	1963	3264.5	8	1.891	423
98	14	1964	3318.4	19	2.722	698
99	13	1965	3323.6	26	2.423	1073
100	12	1966	3289.3	26	1.780	1461
101	11	1967	3347.2	27	1.588	1700
102	10	1968	3420.3	39	1.612	2419
103	9	1969	3481.4	39	1.383	2820
104	8	1970	3491.3	27	0.899	3003
105	7	1971	3427.6	26	0.889	2925
106	6	1972	3469.6	18	0.498	3613
107	5	1973	3593.7	25	0.643	3891
108	4	1974	3541.7	10	0.324	3088
109	3	1975	3639.8	7	0.326	2146
110	2	1976	3607.4	7	0.233	3009
111	1	1977	3514.9	5	0.241	2078
112	0	1978	3284.2	1	0.709	141

Table B3 (con't)

BRAKE DEFECT DATA
WET ACCIDENTS

ACCIDENT YEAR=1978

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
113	19	1960	3567.2	2	5.405	37
114	18	1961	3306.4	2	3.226	62
115	17	1962	3186.3	5	2.809	178
116	16	1963	3130.0	5	1.475	339
117	15	1964	3329.7	11	2.037	540
118	14	1965	3312.0	20	2.232	896
119	13	1966	3252.0	22	1.603	1372
120	12	1967	3307.4	33	2.210	1493
121	11	1968	3406.9	39	1.852	2106
122	10	1969	3483.3	41	1.541	2660
123	9	1970	3467.9	35	1.271	2753
124	8	1971	3459.9	28	0.959	2920
125	7	1972	3478.4	35	0.971	3606
126	6	1973	3624.3	19	0.485	3919
127	5	1974	3570.7	20	0.616	3246
128	4	1975	3699.5	11	0.495	2224
129	3	1976	3590.1	10	0.331	3022
130	2	1977	3497.9	9	0.281	3203
131	1	1978	3253.0	5	0.261	1914
132	0	1979	3166.6	0	0.000	137

ACCIDENT YEAR=1979

OBS	AGE	MODYEAR	WEIGHT	BRAKEDEF	PERCENT	TOTAL
133	20	1960	3500.8	0	0.000	43
134	19	1961	3306.4	0	0.000	47
135	18	1962	3233.2	6	3.896	154
136	17	1963	3239.9	7	2.555	274
137	16	1964	3329.1	15	3.488	430
138	15	1965	3321.3	19	2.599	731
139	14	1966	3247.6	25	2.458	1017
140	13	1967	3303.6	27	2.231	1210
141	12	1968	3403.3	54	2.928	1844
142	11	1969	3480.0	47	1.938	2425
143	10	1970	3471.5	35	1.450	2414
144	9	1971	3446.3	48	1.653	2904
145	8	1972	3496.9	62	1.716	3614
146	7	1973	3621.1	38	0.899	4226
147	6	1974	3570.9	40	1.206	3317
148	5	1975	3696.8	14	0.553	2530
149	4	1976	3630.6	21	0.634	3314
150	3	1977	3518.5	18	0.532	3384
151	2	1978	3265.6	20	0.574	3482
152	1	1979	3121.4	20	0.989	2022
153	0	1980	2708.1	0	0.000	78

Table B4

OLDER MODEL FRONT - REAR DATA

ACCIDENT YEAR=1971

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
1	12	1960	3629.3	583	55.261	1055
2	11	1961	3420.8	701	57.743	1214
3	10	1962	3396.9	1277	54.854	2328
4	9	1963	3402.7	1665	52.723	3158
5	8	1964	3406.0	1955	51.232	3816
6	7	1965	3396.7	2306	48.222	4782
7	6	1966	3317.4	2446	48.493	5044
8	5	1967	3364.0	2288	48.941	4675
9	4	1968	3440.5	2558	46.509	5500
10	3	1969	3473.6	2842	48.482	5862

ACCIDENT YEAR=1972

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
11	13	1960	3655.5	293	54.259	540
12	12	1961	3394.9	447	56.943	785
13	11	1962	3371.5	837	55.102	1519
14	10	1963	3394.3	1143	51.141	2235
15	9	1964	3394.8	1478	50.426	2931
16	8	1965	3392.9	1928	50.078	3850
17	7	1966	3329.4	2194	49.649	4419
18	6	1967	3379.8	2007	49.239	4076
19	5	1968	3449.9	2327	48.499	4798
20	4	1969	3490.3	2401	47.629	5041

ACCIDENT YEAR=1973

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
21	14	1960	3652.3	126	50.806	248
22	13	1961	3445.1	165	54.455	303
23	12	1962	3333.0	403	51.272	786
24	11	1963	3358.0	567	50.400	1125
25	10	1964	3387.2	816	52.308	1560
26	9	1965	3379.6	1098	49.818	2204
27	8	1966	3314.7	1345	51.711	2601
28	7	1967	3368.5	1262	50.179	2515
29	6	1968	3427.8	1563	48.631	3214
30	5	1969	3471.0	1576	47.356	3328

Table B4 (con't)
OLDER MODEL FRONT - REAR DATA

---------------------------- ACCIDENT YEAR=1974 ----------------------------

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
31	15	1960	3666.7	81	56.250	144
32	14	1961	3341.0	86	53.416	161
33	13	1962	3335.0	244	52.586	464
34	12	1963	3363.1	369	52.790	699
35	11	1964	3361.0	530	51.060	1038
36	10	1965	3416.0	778	51.151	1521
37	9	1966	3306.7	1024	51.200	2000
38	8	1967	3373.3	979	49.822	1965
39	7	1968	3445.5	1238	49.579	2497
40	6	1969	3492.7	1297	46.042	2817

---------------------------- ACCIDENT YEAR=1975 ----------------------------

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
41	16	1960	3503.0	32	47.761	67
42	15	1961	3316.3	54	46.154	117
43	14	1962	3366.5	166	53.548	310
44	13	1963	3337.6	278	51.292	542
45	12	1964	3403.5	389	48.808	797
46	11	1965	3343.6	626	51.693	1211
47	10	1966	3312.0	808	52.776	1531
48	9	1967	3343.0	845	50.751	1665
49	8	1968	3428.4	1023	47.471	2155
50	7	1969	3486.6	1196	46.939	2548

---------------------------- ACCIDENT YEAR=1976 ----------------------------

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
51	17	1960	3727.1	33	57.895	57
52	16	1961	3373.2	48	49.485	97
53	15	1962	3254.8	122	51.477	237
54	14	1963	3287.5	210	48.499	433
55	13	1964	3361.0	375	53.267	704
56	12	1965	3360.5	525	50.529	1039
57	11	1966	3281.3	693	50.181	1381
58	10	1967	3353.4	768	51.200	1500
59	9	1968	3431.3	1026	48.237	2127
60	8	1969	3484.8	1204	47.495	2535

Table B4 (con't)

OLDER MODEL FRONT - REAR DATA

ACCIDENT YEAR=1977

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
61	18	1960	3622.9	22	61.111	36
62	17	1961	3478.2	28	48.276	58
63	16	1962	3235.3	76	53.901	141
64	15	1963	3269.5	155	52.542	295
65	14	1964	3367.6	247	52.220	473
66	13	1965	3328.0	372	51.029	729
67	12	1966	3280.2	526	48.659	1081
68	11	1967	3321.2	593	51.253	1157
69	10	1968	3438.9	900	49.806	1807
70	9	1969	3488.2	1048	48.744	2150

ACCIDENT YEAR=1978

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
71	19	1960	3598.9	16	61.538	26
72	18	1961	3357.8	27	56.250	48
73	17	1962	3227.6	66	54.545	121
74	16	1963	3184.1	131	51.575	254
75	15	1964	3320.2	212	47.640	445
76	14	1965	3298.1	343	51.424	667
77	13	1966	3279.8	498	53.092	938
78	12	1967	3326.5	577	51.656	1117
79	11	1968	3421.6	810	49.330	1642
80	10	1969	3486.6	998	47.479	2102

ACCIDENT YEAR=1979

OBS	AGE	MODYEAR	WEIGHT	FRONTALS	PERCENT	TOTAL
81	20	1960	3500.8	14	56.000	25
82	19	1961	3306.4	20	60.606	33
83	18	1962	3233.2	60	58.252	103
84	17	1963	.	109	56.186	194
85	16	1964	.	129	44.637	289
86	15	1965	.	230	46.465	495
87	14	1966	3241.5	337	48.350	697
88	13	1967	3296.3	431	49.654	868
89	12	1968	3430.2	638	48.407	1318
90	11	1969	3475.0	779	47.616	1636