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DEVELOPMENT OF MULTIVARIATE EXPOSURE AND FATAL ACCIDENT INVOLVEMENT RATES FOR 1977

P. Mengert
R. Bair
R. DiGregorio
P. Hoxie
R. Mumford

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SPONSOR: Robert Arnold, NRD-31
National Center for Statistics and Analysis
National Highway Traffic Safety Administration

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Chief, Operator Performance
and Safety Analysis Division

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EXECUTIVE SUMMARY

The need for multivariate accident involvement rates is often encounted in accident analysis. The FARS (Fatal Accident Reporting System) files contain records of fatal involvements characterized by many variables while NPTS (National Personal Transportation Survey) contains reports of trip records similary characterized by many variables. When the classificatory variables available in both data bases are examined the following are indentified as of the most interest in accident analysis:

Driver Age
Driver Sex
Vehicle Weight
Vehicle Age
Land Use (urban/rural)
Season (winter/summer)
Time of Day
Number of Occupants

The fatal involvement data (from FARS) and the VMT data (from NPTS) were separately classified by these variables (each limited to two or three levels). Missing data was accounted for. Missing weight data was estimated, where possible, based on make, model, and/or other vehicle characteristics.

Log-linear models were fit to the classified data to improve the accuracy and statistical stability. Esimates of standard errors were produced by sample splitting techniques. Specifically, random repeated replications were used. Standard errors were calculated for the fatal involvement estimates, for VMT estimates and for fatal involvement rates (the ratio of fatal involvements to VMT). Tables 3.2, 3.4 and 3.5 give multivariate estimate of fatal involvement, VMT, and fatal involvement rates respectively from log-linear models while Tables 4.1, 4.2, and 4.3 give the respective standard errors.

The fatal involvement rate estimates were used to study the question of whether small cars or large cars are more involved in fatal accidents controlling for driver and amount and type of driving. It was concluded that small cars are

overinvolved in fatal accidents overall, but in urban situations especially with younger drivers and perhaps with newer cars, the results suggested that smaller cars are less involved than larger cars in fatal accidents. Note that a fatal collision between a small car and a large car counts as a fatal involvement for both cars regardless of which vehicle had a fatality in it. Consequently, a lower fatal involvement rate for small cars in some situation does not imply that smaller cars are "safer" in those situations. A lower fatal involement rate for a type of car means a lower tendency to be involved in fatal accidents and does not at all necessarily mean fewer fatalities to occupants of the car.

DEVELOPMENT OF MULTI-VARIATE FATAL ACCIDENT INVOLVEMENT RATES

1.0 INTRODUCTION

The objective of this study was to develop multi-variate fatal accident involvement rates. Multi-variate rates are necessary to understand the influence of a factor while controlling for other factors. For example, in deciding whether older cars are more frequently involved in fatal accidents per mile than newer cars, it is necessary to compare older cars with newer cars when driven by similar drivers and when driven in similar circumstances. If the comparison is made without regard to the driver or driving situation, the effect measured could be simply differences in driver or situation.

We have used accident involvement rate measured per vehicle mile of travel (VMT) because VMT is the most appropriate general measure of exposure to accident situations. Fatal accident involvements are used rather than fatalities because we hope to measure risk associated with active participants, the drivers rather than passengers, the passive victim. Further, involvement in a fatal accident rather than involvement in a vehicle whose driver or passenger died is a more appropriate measure of this risk. So, we count as a fatal involvement, any driver or vehicle involved in a fatal accident whether or not a fatality occured in that vehicle.

The most serious obstacle in developing multi-variate involvement rates is obtaining reliable multi-variate exposure (VMT) data. The best source of such data is the 1977 National Personal Transportation Survey (NPTS). The NPTS is a statistical survey in which a collection of households are selected and interviewed. This survey was a stratified, multi-stage cluster design in which 17,000 households were interviewed and their trip patterns were documented for the previous day.* The survey was designed to represent all household trips in the U.S. in 1977. The NPTS is described and the general results are presented in a series of reports by the Federal Highway Administration.

*Longer trips were also identified for the prior week, but those trips were not used in this study because they would over-represent long trips in the aggregate if they were included.

A serious difficulty in using the NPTS data has been the ambiguity in constructing the weights by which the sample trip is scaled up to U. S. total VMT. "User's Guide to the SAS Version of the 1977 NPTS" by R. Bair, who also participated in this study, documents a new Statistical Analysis System (SAS) file containing the NPTS data and presents some illustrative examples which show how to calculate weighting factors for households, trips, and vehicles.

The fatal involvement data are taken from the 1977 Fatal Accident Reporting System (FARS) which contains data on every fatal motor vehicle accident in 1977.

Table 1.1 presents the dimensions used in creating the multi-variate fatal involvement rates. These eight dimensions represent all of the variables which are common to both NPTS and FARS which might affect accident involvement rates. The levels or categories in each dimension are also identified in Table 1.1. Section 2.0 documents how the FARS and NPTS data were classified into these dimensions and levels.

The levels were chosen to minimize the total number of categories into which the data would be classified. The eight dimensions and associated levels shown in Table 1.1 lead to 576 separate cells. Each VMT in NPTS and fatal accident involvement in FARS must be classified into one of these cells. The levels were minimized to keep the resulting cell counts as high as possible because the size of the cell count influences the reliability of the estimated fatal involvement rate. Log linear models were fit to both the FARS and NPTS data to further improve the reliability of the cell estimates. This process is described in Section 3.0 along with the resulting smoothed fatal involvement rates.

The standard error of each cell in the FARS fatal involvement array, the NPTS VMT array and in the fatal involvement rate array is presented in Section 4.0, along with the methods used to estimate these standard errors. The standard error is needed in order to judge the significance of observed differences in fatal accident involvement rates.

Finally, Section 5.0 presents an example of how these fatal accident involvement rates and the associated standard errors can be used to assess the relative fatal involvement rates of small and large cars.

Table 1.1 Dimensions and Levels of Multivariate Fatal Involvement Rates

Dimensions	Levels
Driver Age	LE 25
	26-55
	GE-56
Driver Sex	Male
	Female
Vehicle Age	LE 5
	GE 6
Vehicle Weight	LE 3000 lbs.
	GT 3000 lbs.
Number of Occupants	1
	GE 2
Time of Day	Late Night
	Rush Hour
	Other
Land Use	Urban
	Rural
Season	Summer
	Winter

2.0 CLASSIFICATION OF NPTS AND FARS DATA

This section describes the procedures for classifying of NPTS and FARS data for inclusion in the fatal accident involvement rate analysis. The NPTS and FARS data bases were examined to determine the extent of overlap between variables in the two data bases. Only variables found on both data bases are useful in developing fatal involvement rates. Eight common variables or dimensions were identified for this analysis. The eight dimensions are listed in Table 1.1. Detailed definitions of the levels for FARS and NPTS appear in Table 2.1. Observations in each of the data bases are distributed to the resulting 576 element array based on these definitions.

In order to assure that the fatal accident rates derived from the NPTS and FARS data are as accurate as possible care was taken to ensure that both FARS and NPTS arrays counted vehicles of precisely the same types: passenger cars including station wagons. Further, the definitions of the dimensions and levels in NPTS and FARS were matched as closely as possible because any mismatch could strongly distort the fatal involvement rates. Finally, missing data was carefully accounted for and missing values in either data set were reduced to very low levels by estimating the missing values from other information known about the vehicle or driver.

The remainder of this section describes the steps taken to develop the mutli-variate FARS and NPTS arrays, accounts for the missing data, and explains the methods used to estimate the missing values.

2.1 FARS/NPTS Working File Development

All fatal involvement data in this analysis originates from the 1977 FARS file. VMT data were extracted from the 1977 NPTS file. Subsets of the FARS and NPTS data files were constructed for this analysis. Development of the FARS working file from the original 1977 FARS is summarized in Figure 2.1. The NPTS working file development is summarized in Figure 2.2

2.1.1 FARS Working File Development

The 1977 FARS file is divided into three segments: the person level file with 111,108 records; the vehicle/driver level file containing 61,254 records; and the

Table 2.1

Definitions of Variables Used in Fatal Accident Involvement Rate Analysis

			FARS Code	NPTS Code
SEASON	Summer	April, May, June, July, August, September	Month = 4, 5, 6, 7, 8, 9	Interview Month = 4, 5, 6, 7, 8, 9
	Winter	October, November, December, January, February, March	Month = 10, 11, 12 1, 2, 3	Interview Month = 10, 11, 12, 1, 2, 3
LAND USE	Urban	Urban Area	Land Use = 1	Urban VMT
	Rural	Non-urban Area	Land Use = 2	Rural VMT
VEHICLE AGE	New	5 years old or less	Mod-year = 73-78	Model Year = 73-78
	Old	greater than 5 years old	Mod-year less than 73	Model Year = earlier than 73
NUMBER OF OCCUPANTS	One	Driver Only	Occupants = 1	Total # of persons in in the vehicle = 1
	More than one one	Driver with passenger(s)	Occupants GT 1	Total # of persons in and Occupants LE 96 vehicle GT 1
TIME OF DAY	Rush Hour	M-F 6:00-8:59 a.m. 3:30-6:29 p.m.	(day-week=2-6) and (600 LE time LE 8:59) LE 1829)	(day-week=2-6) and (600 LE time of travel or (1530 LE time LE 859) or (1530 LE time of travel LE 1829) Where TIME OF TRAVEL = time trip started plus length of time to reach destination.

Table 2.1

Definitions of Variables Used in Fatal Accident Involvement Rate Analysis (Cont'd)

	Late Night	9:30 p.m. - 5:59 a.m.	Time GE 2130 or (0 LE Time LE 559)	Time of Travel GE 2130 or (0 LE Time of Travel LE 559)
	Other	all else	all other times	all other times
DRIVER SEX	Male	Male	Sex = 1	Sex = 1
	Female	Female	Sex = 2	Sex = 2
DRIVER AGE	Young	Less than 26 years old	Age LE 25	Age LE 25
	Middle-aged	26-55 years old	(Age GE 26 and Age LE 55)	(Age GE 26 and Age LE 55)
	Older	Over 55 years old	Age GT 55	Age GT 55
VEHICLE WEIGHT	Light	LE 3000 pounds	VIN_WGT LE 3000	Shipping Wt LE 3000
	Heavy	GT 3000 pounds	VIN_WGT GT 3000	Shipping Wt GT 3000

Figure 2.1

Development of FARS Working File:
Summary of 1977 Record Distribution FARS Working File

51,059
non-drivers

person level
111,108

drivers only

60,049

autos and
their drivers
38,419

38,696
automobiles

vehicle driver level
61,254

other body
types
22,558

accidents,
autos,
drivers
38,419

37,988
final working
file

unknown
values
431

accident level
42,211

Figure 2.2

NPTS Working File Development

	Total Trips	Total VMT ($*10^9$)
NPTS segment 5	96,974	
Trips in household vehicles	67,299	880.5
Trips in household vehicle with driver and vehicle records matching	65,435	807.3
Total trips in passenger cars with known values for all dimensions excepting vehicle weight	55,594	672.2

accident level file, consisting of 42,211 records. The FARS working file was developed as follows:

1. Only person level records in which the person was identified as a vehicle driver were retained. There were 60,049 records identified as driver records in the person level file. The remaining 51,059 records in the person level FARS file were dropped from the subsequent analysis.

2. Only vehicle records with "body type of automobile" were retained from the vehicle/driver level file. This subgroup, amounting to 38,696 vehicles was designated as passenger cars. Truck, motorcycle and moped body types, numbering 22,558 records, were dropped from further consideration.

3. The driver and passenger car subfiles were merged. As a result, 38,419 records remained. Drivers of vehicles other than passenger cars, and vehicles with no driver (e.g. parked cars) had no match during this merge step.

4. The accident level file was merged with the person/vehicle level file of Step 3. At this point, the FARS working file contained 38,419 records.

5. If data for any of the eight dimensions, with the exception of vehicle weight are missing on a record, it is not possible to assign the record to one of our 576 cells. An additional 431 records were dropped as a result of this step leaving 37,988 fatal involvements. Some of these records had unknown values for more than one of the dimensions. The total number of instances of unknown values for each of the dimensions other than vehicle weight follows.

Number of records with unknown values for:

sex -	5
age -	83
model year -	213
no. of occupants -	172
time of day -	84
land use -	91
season -	0

Section 2.3 discusses the methods used to assign vehicle weight to records with unknown weight.

2.1.2 NPTS Working File Development

The 1977 NPTS contains detailed information on 96,974 travel day trips. The total number of trips made in a household vehicle amounts to 67,299 trips with $880.5*10^9$ VMT using the "total distance to destination" field also known as the reported distance. This total compares well with the total of 880,163,000,000 reported VMT which is listed on page 29 of the 1977 NPTS User's Guide. Since trips had to be disaggregated into urban and rural VMT components for the subsequent analysis, mapped VMT rather than reported VMT is used in the working file. The total mapped mileage for household vehicles is $838.0*10^9$ VMT. The ratio of reported to mapped VMT which these calculations yield is 1.051. This ratio compares favorably to the ratio of 1.056 deriveable from the figures contained in FHWA report No. 8, Urban/Rural Split of Travel (page 7) from the FHWA series of reports on the 1977 NPTS.

The total of all trips in a household vehicle for which both a driver and a vehicle record are present equals 65,435 trips and $807.3*10^9$ VMT. Certain groups of trips other than those with missing vehicle weights were discarded from the analysis because not all the desired dimensions are present on those records. They account for $14.9*10^9$ VMT and are distributed as follows:

missing time of day :	$5.0 * 10^9$ VMT
no vehicle age :	$1.8 * 10^9$ VMT
NPTS vehicle type = 7,8,9,12,999 :	$4.1 * 10^9$ VMT
unable to assign weight :	$4.1 * 10^9$ VMT

At this stage of its development, the NPTS working file contains 64,167 trips with $792.4*10^9$ mapped VMT. The distribution of these trips and VMT to vehicle type categories is summarized in Table 2.2. Since the remainder of this analysis

Table 2.2

Distribution of Trips to Vehicle Type Categories

Vehicle Type	Total Records 64,167 % Records	Mapped VMT $792.4*10^9$ % Mapped VMT
1	76.55	75.25
2	10.09	9.58
3	1.94	2.36
4	.62	.79
5	9.70	10.66
6	.58	.78
10	.51	.57
11	.01	.01
	100.00	100.00

focuses on passenger cars only, the total of trips and VMT for passenger cars only, namely vehicle types 1 and 2, amounts to 55,594 trips and $672.2*10^9$ VMT. All of the desired dimensions with the exception of vehicle weight are well defined in this group of trips. Unknown vehicle weights are present on 8783 trips which represent $109.9*10^9$ VMT. A full description of the NPTS weight assignment process follows in section 2.3.2.

2.2 Definition of Variables in FARS/NPTS Working Files

Variables in FARS and NPTS were compared to ensure consistency between the two data sets. Some of the dimensions, such as age, sex, time of day/day of week, and number of occupants are easy to construct in a comparable way for the two data sets. Two definitions - vehicle weight and land use - are not obvious, however.

Land Use: The FARS and NPTS working files both use the FHWA classification of roadways to determine whether an area is rural or urban. A fatal accident such as those reported in FARS occurs at a specific location. That location can be categorized as urban or rural based on the FHWA classifications. However, it is much more difficult to categorize entire trips which cross several land use types. Trips in the NPTS file were disaggregated into urban and rural VMT components based on the mileage mapping that was performed by FHWA and included in the NPTS data tape. As noted in the section of this chapter which deals with development of the NPTS working file, the VMT calculated using mapped mileage is somewhat lower than the VMT total using reported mileage in NPTS. The total difference between reported VMT and mapped VMT is $42.5*10^9$ VMT. That total difference is distributed as follows: 1,564 records and $28.5*10^9$ VMT are associated with trips which have reported VMT but no mapped VMT; $4.7*10^9$ VMT is the excess of reported VMT over mapped VMT for the 2,537 records in which a portion of the trip is off the map; $0.9*10^9$ VMT is the excess of reported VMT over mapped VMT for the 1,881 records which are all off the map; and $8.4*10^9$ VMT represents the excess of reported VMT over mapped VMT for all other trips. The equations for calculating VMT are the same whether reported or mapped mileage is chosen. The product of the time inflation factor and household trip weight is applied to each mileage and the result is summed over all records.

Vehicle Weight: The vehicle weight field reported in the FARS data base is vehicle shipping weight. The vehicle identification number (VIN) is recorded on the FARS data collection forms. However, to protect privacy rights, the VIN is not recorded in the FARS data base. Instead, the VIN is used as input to the VINA computer program available from the R. L. Polk Company. VINA in turn derives a series of useful characteristics from the VIN including vehicle make, model, and shipping weight. In the case of NPTS, it was necessary to use shipping weight to ensure that the same weight definitions are being used in both working files.

A comparison of vehicle weights for comparable vehicles was performed for selected makes and models of autos present in both FARS and NPTS. The results are detailed in Table 2.3. Specific vehicles were included in the comparison if the vehicle make and model was represented on at least 30 records in each data base. Mean weights for each make/model in the comparison were computed separately for FARS and NPTS. While there are differences in the average shipping weights between the data bases, the differences are not large enough or one-sided enough to cause any of these make/model vehicles to be incorrectly classified as large or small vehicles. The simple average of the weight differences is only 14 pounds. As a result, there does not appear to be systematic difference between the reporting of vehicle weights in the two data bases.

2.3 Vehicle Weight Assignment Methods

In both FARS and NPTS data bases, a substantial number of vehicle records contained unknown values for vehicle weights. A good deal of effort was expended during this study to assign weights to these vehicle records. The objective was to maximize the size of the FARS and NPTS working files which could be utilized as input to the multivariate analysis. If groups of records with unknown weights were deleted from the FARS and NPTS working files, it could result in misleading results in the multivariate analysis. Generally, weights were assigned when other records with known vehicle weights and identical model year, make and model information were available. Details of methods used to assign weights to records appear below.

Table 2.3

Comparison of Vehicle Weights for Selected Model Automobiles: FARS and NPTS

Make	Model	FARS Mean Weight	(Sample Size)	NPTS Mean Weight	(Sample Size)	Difference (lbs.)
Chrylser	Cordoba	4130.0	(52)	4000.0	(34)	130.0
Dodge	Aspen	3237.8	(32)	3234.4	(32)	3.4
Plymouth	Volare	3270.4	(37)	3239.6	(36)	39.8
Ford	LTD	4341.2	(84)	4300.0	(57)	41.2
	Granada	3136.5	(103)	3302.0	(98)	-165.5
Buick	Century	3655.1	(61)	3829.1	(51)	-174.0
Chevrolet	Malibu	3706.7	(63)	3787.0	(46)	-80.3
	Nova	3218.2	(90)	3342.2	(64)	-124.0
	Camaro	3468.0	(66)	3464.3	(42)	3.7
	Chevette	1923.1	(56)	1900.0	(37)	23.1
Oldsmobile	Cutlass	3707.6	(118)	3794.8	(96)	87.2
Pontiac	Grand Prix	4044.2	(72)	4000.0	(45)	44.2

Total of Differences = -171.2 lbs.

Average Difference = -14.27 lbs.

2.3.1 FARS Vehicle Weight Assignment Algorithm

The FARS weight assignment process involves four steps. First, fatal involvement records with known vehicle weights were assigned to one of two categories: light (if vehicle weight was less than or equal to 3000 pounds) or heavy (if vehicle weight was greater than 3000 pounds). There are a total of 37,988 records in the FARS working file. In this step, 27,803 fatal involvement records were classified into one of the two weight categories. The remaining 10,185 fatal involvement records did not have a known vehicle weight.

Second, both the vehicles with known weights and those without known weights were grouped together by common make, model, and model year. Within each group of records with these common characteristics, the number of vehicles classified in the light category and those classified in the heavy category were totaled. Those vehicles with unknown weights were then assigned to the two weight categories based on the proportion of the vehicles with known weights which were in each weight category. 4,839 records were assigned to vehicle weight categories during this step.

The third step was similar to the second step. Records were grouped by common make and model year.* Those vehicles with unknown weight which had not been assigned to the light or heavy categories, as a result of step two, were assigned to a category based on the proportion of those vehicles within the same group which were already categorized as light or heavy. Another 4,367 records were assigned weight categories during the third step.

After these three steps, 979 vehicles remained unclassified by vehicle weight. In this final step, all records were again regrouped by make and age of vehicle. Two age groups were used. Those vehicles less than or equal to five model years and those vehicles older than five model years. Another 312 records were assigned to weight categories based on the age/make combination.

After the fourth step, 667 records were unassigned. The final 1977 FARS fatal accident involvement array was constructed from the remaining 37,321 FARS involvement records.

*Vehicles with model year earlier than 1967 were classified as 1967.

2.3.2 NPTS Vehicle Weight Assignments

The NPTS vehicle weight assignment process is summarized in Table 2.4. NPTS contains not one, but three distinct vehicle weights. Curb weight, shipping weight, and inertial weight are all reported in NPTS. Since FARS makes use of shipping weight, all NPTS weights are converted to shipping weight so that valid comparisons can be made in this analysis. In the event that shipping weight is reported in NPTS, that weight is used directly. If there is no shipping weight in NPTS, but curb weight is reported, then curb weight is converted to shipping weight using the relationship: shipping weight = curb weight - 100. If neither shipping weight nor curb weight is reported, but inertial weight is reported in NPTS, then inertial weight is converted to shipping weight using the relationship: shipping weight = inertial weight - 400. The relationships among shipping weight, curb weight and inertial weight were derived from an analysis of the differences in the mean shipping curb and inertial weights for vehicles in which at least two weights were reported. The average difference between curb weight and shipping weight was 123 pounds. Since NPTS reports weight only to the nearest hundred pounds, the average difference was rounded down to 100 pounds for the purpose of imputing weights. The average difference between inertial weight and curb weight was 300 pounds, hence the difference between inertial weight and estimated shipping weight of 400 pounds.

The number of trips in which shipping weight is given is 23,271 with $282.2*10^9$ VMT. The number of trips in which shipping weight was derived from curb weight is 23,473 with $279.5*10^9$ VMT. The number of trips in which shipping weight was derived from inertial weight is 67 with $0.636*10^9$ VMT. The total number of passenger car trips with known vehicle weight is 46,811. They account for $562.3*10^9$ VMT. This leaves 8,783 passenger car trips and $109.9*10^9$ VMT to be assigned to weight categories.

The final step requires that the remaining records, which have no reported weight, be assigned to one of the two vehicle type categories. VMT is assigned to each vehicle weight category based on the vehicle age, make, number of cylinders, and weight information for the 46,811 vehicles with known weights.

Table 2.4

NPTS Weight Assignment Process

	Total Trip Records	Total VMT(10^9)
all passenger cars	55,594	672.2
shipping weight known	23,271	282.2
shipping weight derived from inertial weight	67	0.636
shipping weight derived from curb weight	23,473	279.5
Total known weights	46,811	562.3
Total assigned weights	8,783	109.9

The process of imputing VMT to vehicle weight categories makes use of a look-up table in which vehicles with known weight and vehicle type are grouped into a matrix.* The matrix is based on vehicle make, number of cylinders, and model year. Three cylinder types are used: 4 cylinders, 6 cylinders, and 8 cylinders. Four model year groupings are used: 1971 and earlier; 1972 and 1973; 1974 and 1975; and 1976 and later. The mapped VMT for each of the passenger cars with known weight is assigned to one of the matrix cells based on make, model year, and number of cylinders. For passenger cars with unknown weight, the mapped VMT is assigned to vehicle weight categories based on the proportion of vehicles with the same make, model year, and number of cylinders with known vehicle weights. E.g., if 40 percent of the 4 cylinder 1980 Chevrolets with known weight are in the less than 3,000 pound category, then a 4 cylinder 1980 Chevrolet with unknown weight would have 40 percent of its mapped VMT assigned to the lower weight category and 60 percent of its mapped VMT assigned to the higher weight category.

Of the 8,783 records and $109.9*10^9$ VMT with unknown weights, 3,840 records with $53.045*10^9$ VMT are perfectly categorized by vehicle weight. A perfect categorization, in this sense, means all vehicles with known weight for a particular make, model year and cylinder count fall into the same weight category, either the lower or the higher category. In the course of the VMT assignment process, the proportion of vehicles in each weight category which have known weight and the same make, model year, and number of cylinders is computed. The smaller of the two proportions is called Pmin. In the case of perfect assignment, Pmin = 0. Two additional quantities were calculated for all records with assigned weights:

$$VMT*Pmin = 7.426*10^9$$

$$VMT*(Pmin)^2 = 1.933*10^9$$

These results show that the Pmin values tend to be low. This means that very little VMT was actually split between vehicle weight categories, and the vehicle make, model year, and number of cylinders is quite good at discriminating between heavy and light vehicles which lends confidence in the weight assignment results.

*Model was not used in the weight assignment process since those records which had a model designated also had a weight designated.

After the trip records with unknown vehicle weight had been assigned as far as possible by the above described procedure to the light and heavy vehicle category, the percent distribution of VMT by vehicle weight was: heavy: 68.3 percent; light, 31.7 percent (see Table 3.5 described in next section). The same distribution was calculated for only the records with known VMT with the resulting distribution: heavy: 70.1; light: 29.8.

The difference is due to the fact that the records with unknown vehicle weight, 17 percent of all VMT, when assigned to the heavy and light categories had a different. distribution than the records of known vehicle weight. It can be calculated that the records with missing vehicle weight were assigned in the proportion of about 60 percent to 40 percent heavy to light.

This higher percentage of light vehicles in the records with missing weight information leads to the increase from 29.8 percent light in the records with known weight to 31.7 percent light in the overall VMT. Note that a shift of only one percent of the VMT from light to heavy would change 31.7 percent light to 29.7 percent light.

2.4 Preliminary FARS/NPTS Frequencies

Table 2.5 summarizes the univariate frequencies of all the dimensions and levels of the FARS and NPTS working files. The total counts for fatal involvements in Table 2.5 do not exactly agree with the total of fatal involvements in the FARS working file (37,321) because of rounding errors. However, the general results of these univariate frequencies are reasonable and provide confidence in use of the FARS and NPTS final working files as input to the multi-variate analysis.

Since the Polk tapes record vehicle registration for 1977 a special test was run to see whether the NPTS counts of vehicles in Classes 1 and 2 in the light and heavy categories agreed with the Polk registration counts. The results reported in Table 2.6 are quite satisfactory.

Table 2.5

Comparison of Frequencies in FARS/NPTS Fatal Involvements Rate Analysis

	Total VMT (x 10^9)	% Total VMT	Total Fatal Involvements	% Total Fatal Involvements	Fatal Involvements VMT (10^9)
Driver Age					
=25 years	154.8	23.0	16,801	45.0	108.53
26-55	417.9	62.2	14,908	40.0	35.67
55	99.0	14.7	5,600	15.0	56.57
Driver Sex					
Male	437.0	65.1	27,987	75.0	64.02
Female	234.7	34.9	9,332	25.0	39.76
Season					
Summer	355.3	52.9	19,563	52.4	55.06
Winter	316.4	42.7	17,746	47.6	56.09
Land Use					
Urban	421.6	62.8	16,573	44.4	39.31
Rural	250.1	37.2	20,736	55.6	82.91
Vehicle Age					
LE 5 years old	387.6	57.7	15,807	42.4	40.78
GT 5 years old	284.1	42.3	21,502	57.6	75.68
Vehicle Weight					
LE 3000 lbs.	212.6	31.7	12,504	33.5	58.81
GT 3000 lbs.	459.1	68.3	24,805	66.5	54.03
Time of Day					
Other	381.2	56.8	16,962	45.5	44.50
Rush Hour	223.7	33.3	6,338	17.0	28.33
Late Night	66.8	9.9	14,009	37.5	209.72
Occupants					
Driver Only	367.8	54.8	19,793	53.1	53.81
Driver & Passengers	303.9	45.2	17,516	46.9	57.64

Table 2.6

Comparison of NPTS with Polk on Cars and Stationwagons by Weight

	Total Vehicles/10^6	Precent* Heavy	Percent* Light	Percent With Unknown Weight
Polk 1978**	100.7	69.6	30.5	16.9
NPTS	95.5	69.4	30.6	19.9

*Percentages for Heavy and Light are of vehicles with known weights.

**Polk 1978 covers registrations in 1977.

3.0 IMPROVING THE ACCURACY OF THE FATAL INVOLVEMENT RATES USING LOG-LINEAR MODELS

3.1 Introduction

When the FARS fatal accident involvement counts and the NPTS VMT totals are distributed over the multidimensional tables with 576 cells each, many of the cells are "noisy," i.e. their contents (in counts or VMT) are subject to sampling error.* In the extreme, some of the cells are empty (three empty cells are observed in the case of NPTS (see Table 3.3) and 1 in the case of FARS (see Table 3.1). Further evidence of the noisiness of the data is presented in Sections 3.3 and 4.4. Because of the noisiness of the raw data, accurate estimates of fatal involvement rates cannot be obtained by simply dividing the raw FARS cell counts by the raw NPTS cell VMT sums. It is desirable to first "smooth" the FARS and NPTS tables in order to obtain more accurate cell estimates.

Probably the best available method to accomplish this smoothing is through the application of log-linear models.** Log-linear models were used to produce all the estimates contained in this study. A substantial increase in accuracy resulted from this smoothing process (see Sections 3.3 and 4.4 for the evidence).

3.2 The Construction of the Log-Linear Models

This section deals with the general strategy for selecting a log-linear model specification used for this study, more details are given in Appendix A.

*Note that even in the case of FARS the data should be considered a sample (even though FARS records all fatal accidents in the year) since what is of interest is the data for the year 1977 as representative of the fatal accidents in other years.

**A short discussion of the use of the standard maximum likelihood method for fitting log-linear models to count data and a discussion of the formal application of the method to non-count data is found in Reference 1. (A more complete discussion of log linear modelling is found in Reference 2).

In using the classical maximum likelihood approach to fitting hierarchical* log-linear models, the fitted model parameters are determined by certain margins of the data matrix. The selection of the proper margins (which is equivalent to the selection of what interactions to include in the model) is discussed in this section. The reason why the modelled cell estimates are more statistically stable (i.e. have less sampling variance) than the raw cell counts is that the margins of a data matrix have greater (relative) statistical stability than the raw data matrix itself (because they are more aggregate and have cells with larger sample sizes).

The basic approach to model selection is to find the hierarchical log-linear model with highest possible number of (residual) degrees of freedom** and the lowest possible chi square. These two optimization goals are at odds and a tradeoff must be sought.

The primary objective for making this tradeoff should ideally be accuracy. In this case, the tradeoff between high degrees of freedom and low chi square can be viewed in terms of the components of inaccuracy: bias and variance. Bias results from fitting a parsimonious model (one of limited complexity) to a set of data generated by a more complex process.*** Thus, bias is the result of a too parsimonious model, and in general, a less parsimonious, more complex model has lower bias. Variance (sampling variance), on the other hand, is lower for a more parsimonious model. Total (mean squared) error is determined by the two components, bias and variance. The minimum total error occurs at a model of intermediate complexity where neither bias nor variance is extremely large.

*All log-linear models considered in this study are hierarchical. (This is usual, e.g. Reference 2 is devoted exclusively to hierarchical log-linear models.) A hierarchical model is one which contains all lower order interactions associated with any high order interaction it contains. Interactions are terms in a model which depend on a specified combination of variables, e.g. the 1-3-4 interaction depends simultaneously on variables 1, 3, and 4 but not on other variables. More detailed definitions of the terms used here are given in References 1 and 2.

**The degrees of freedom associated with a model are the residual degrees of freedom in the data. This equals the number of data cells minus the number of independent parameters in the model (see Reference 2, p. 114). Thus maximum degrees of freedom is equivalent to minimum model complexity.

***Bias may also be thought of as model misspecification error.

However, to determine the optimum level of complexity, both the bias and the variance must be estimated.

In this study, the bias was not estimated although the variance was. Instead, the complexity of the model is set somewhat arbitrarily at a rather high level with the expectation that the bias will be negligible. If the bias is negligible then all the error is due to the variance and so the smoothed data is necessarily more accurate than the unsmoothed data.* The total error in the cell estimates would then be well characterized by the standard error determined from the variance. Evidence in Appendix A suggests that the models were not underfit (i.e. that the bias is small); furthermore in Section 4.4 it is observed that a very sizeable reduction in the standard error of the cell estimates was obtained by the log-linear model smoothing process. From this it is concluded that the smoothing process substantially increases the accuracy of the cell estimates.

The Model Specification Process

A brief description is given in this subsection of the process used to attempt to find the model with minimum chi square for a given number of degrees of freedom; or maximum number of degrees of freedom (residual) for a given chi square. Basically the strategy is to find a model such that no interaction (in the model) can be replaced by another (not in the model) with the same number of degrees of freedom without increasing the ratio of chi square to degrees of freedom. Before outlining the process in more detail, it should be pointed out that the assumptions needed in log-linear modelling in the classical sense are not satisfied in either the FARS or NPTS case. In the FARS case, the classical assumptions will be invoked as approximately true while in the NPTS case a factor is developed to make the classical chi square statistic approximately valid. The assumptions made and the justifications for them are discussed in Appendix C. In this section and in Appendix A, it will be assumed that both data sets (transformed as necessary by a factor in the NPTS case) are suitable for the application of classical log-linear modelling techniques.

*Since the log-linear modelling process can only decrease the variance.

The ideal goal is to find a model of a certain degree of complexity such that no other model of that degree of complexity (i.e. with the same number of degrees of freedom) has a lower chi square. However, the chi square value for a model can only be obtained by constructing that model and this is expensive. Therefore, the ideal procedure is infeasible due to the prohibitively large number of possible hierarchical models.

In order to describe a compromise procedure which is feasible, some terminology is needed. The increase in the chi square value due to dropping a certain interaction from a certain model or the decrease due to adding a certain interaction to that model will be denoted by ΔX^2.* The (absolute value of the) change in degrees of freedom will be denoted by ΔDF. The ratio $\Delta X^2/\Delta$DF is the quantity of interest.

The compromise goal is to seek a model such that, the value of $\Delta X^2/\Delta$DF for any interaction in the model is greater than the value of $\Delta X^2/\Delta$DF for any interaction not in the model.** It can be seen that if ΔX^2 did not depend on what model it referred to, this procedure would lead to a global rather than a local minimum in chi square for the resulting number of degrees of freedom.

Even this compromise goal is quite ambitious for a matrix as complex as the FARS and NPTS matrices in this study. Before describing the basic steps in searching for a (compromise) optimum model, it is necessary to say some more about how to compute ΔX^2. There are basically three ways of estimating ΔX^2 for interactions (with respect to a given model); these are, in order of decreasing accuracy and decreasing computational cost as follows:

*In words "ΔX^2" is "delta chi square."

**A necesssary exception to this in the case of some lower order interactions "implied by" higher order interactions is discussed later in this section (in a footnote on "dilution").

1. Calculate the value of chi square for the model with the interaction in and for the model with the interaction out. The difference is the most accurate value of ΔX^2.

2. Estimate $\Delta X^2/\Delta DF$ according to the procedure described in Appendix A based on the standardized effects for the model in question. This approximation is essentially exact if the number of degrees of freedom (ΔDF) (independent parameters) in the interaction is 1 and less accurate if the degrees of freedom is greater than 1.

3. Use the standardized effects in the same manner as just described (under item 2) but use the standardized effects for a more complex model which contains the given model as a submodel. This procedure allows $\Delta X^2/\Delta DF$ to be estimated with limited accuracy for a great many interactions at once. This is the least accurate estimate but least costly computationally.

Now a series of models are constructed together with the standardized effect estimates for the interactions in the models. Interactions are added or deleted from intermediate models, each on the basis of whether its $\Delta X^2/\Delta DF$* value is above or below a given threshold (the threshold varies at various stages; see Appendix A).

The final model corrresponds to a fixed threshold (3.0) and has the property that no interaction in the model has a $\Delta X^2/\Delta DF$ (determined in the most accurate manner which involves fitting a separate model corresponding to deleting each interaction) less than 3.0 while no interaction not in the model has an estimated

*In the case of high order interactions for which some implied (by the property of being hierarchical) lower order interactions do not have the required $\Delta X^2/\Delta DF$ the ΔX^2 and ΔDF values are calculated for the higher order <u>and</u> implied lower order interactions together. The resulting $\Delta X^2/\Delta DF$ is then said to be the appropriate "diluted" value pertaining to the higher order interaction. Example: Suppose the threshold for $\Delta X^2/\Delta DF$ is 3.0, that the 1-2-3 interaction has $\Delta X^2 = 4.0$ and $\Delta DF = 1$ but the 1-2 interaction has $\Delta X^2 = 1$ with $\Delta DF = 1$ while the 1-3 and 2-3 interactions have $\Delta X^2/\Delta DF > 3.0$ and are thus in on their own. Then the diluted $\Delta X^2/\Delta DF$ for the 1-2-3 interaction is $(4.0 + 1.0)/(1 + 1) = 2.5$. Thus the 1-2-3 interaction is not entered if the threshold is 3.0 because it would "force in" the weak 1-2 interaction.

$\Delta X^2/\Delta DF$ as great as (or greater than) 3.0. (The $\Delta X^2/\Delta DF$ of 5 way and higher interactions have not been estimated). The $\Delta X^2/\Delta DF$ estimates for most of the interactions not in the model are determined by their standardized effects in intermediate models. However, if a $\Delta X^2/\Delta DF$ estimate is close enough to 3.0 to warrant further consideration, it is reestimated more accurately to determine whether it belongs in the final model.

The resulting model is believed to be a good approximation to, and may well be a model which achieves, the compromise goal described earlier in this subsection. There are, however, far too many interactions not in the model to test each using the most accurate method. Furthermore, such a procedure would be wasteful, since if a $\Delta X^2/\Delta DF$ estimated from standardized effects is small the accurate $\Delta X^2/\Delta DF$ cannot be very large.

3.3 Results of Smoothing

In this section, the results of specifying and fitting log-linear models to the FARS and NPTS data according to the procedures described in Section 3.2 and Appendix A are presented along with the raw data matrices. The ratios of the smoothed cell estimates, the estimated fatal involvement rates, are also presented. Section 4 presents the relative standard errors of the smoothed cell estimates and of the resulting fatal involvement rates.

Table 3.1 shows the raw* fatal involvement data from FARS. It contains the 576 cell counts derived from the 1977 FARS data base as described in Section 2. Note that the fatal involvement counts are not integers because some involvements were fractionally assigned to more than one cell because of incomplete information.

Table 3.2 shows the results of applying log-linear smoothing to the raw data in Table 3.1. The results are the best estimates of fatal involvements for each cell in a typical year like 1977.

*The term "raw data" as used here refers to the data after going through the processes described in Chapter 2 (including vehicle weight estimation in some cases) but before the log-linear modelling process.

Table 3.3 shows the raw* NPTS data as described in Section 2 while Table 3.4 shows the results of log-linear model smoothing of these data. The cell entries in Table 3.4 represent the most accurate estimates of VMT derived from the NPTS data by log-linear model smoothing.

Table 3.5 shows the estimated fatal involvement rates obtained by dividing the 1977 smoothed FARS involvements (Table 3.2) by the corresponding 1977 smoothed NPTS VMT estimate (Table 3.4). The smoothed VMT estimates and the fatal involvement rates made possible by this exposure data are the primary objectives of this project. The next chapter develops the standard errors of these estimates.

The following observations are made on these tables:

1. The raw and fitted data differ substantially, indicating that the smoothing has made a considerable difference in the estimates. When this is coupled with the prior observation (Section 3.1) that the models were not substantially underfit, it indicates a substantial advantage to the smoothing process (further evidence of this will be seen in Section 4 when the standard errors are calculated).

2. The fatality rates show a striking variation from cell to cell (the largest rate is over 200 times the smallest). The extent to which this is just a noisy fluctuation will be discussed in Section 4 where the relative standard errors are given.

*See previous footnote.

TABLE 3.1 RAW FATAL INVOLVEMENT DATA (FARS, 1977)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	58.195	97.865	92.545	218.454	100.475	142.524	141.002	220.997
			26-55	86.276	200.724	97.537	254.462	65.835	237.164	125.426	267.566
			GE 56	24.390	103.610	60.118	149.882	22.463	101.537	76.821	157.176
		FEMALE	LE 25	28.006	45.994	59.847	53.153	33.093	48.907	43.629	76.371
			26-55	43.656	105.344	38.513	86.486	39.165	108.834	38.158	83.842
			GE 56	14.275	35.725	19.775	62.225	17.743	58.257	30.898	58.102
	RUSH	MALE	LE 25	13.366	48.634	42.667	62.333	33.802	60.198	54.103	56.857
			26-55	33.968	92.032	58.138	111.861	33.686	86.314	52.925	56.075
			GE 56	12.291	42.709	30.019	56.981	19.000	32.000	21.129	57.871
		FEMALE	LE 25	22.090	16.910	20.935	24.065	15.551	24.449	36.157	30.643
			26-55	20.507	54.492	13.481	42.519	23.868	45.132	18.983	46.017
			GE 56	4.000	11.000	6.426	30.574	4.950	27.050	7.263	22.737
	LATE	MALE	LE 25	118.925	161.074	157.387	288.608	138.632	221.367	175.924	353.070
			26-55	81.458	260.541	114.886	250.113	79.649	202.350	116.523	289.471
			GE 56	5.596	23.404	17.801	42.199	8.195	35.805	14.358	48.642
		FEMALE	LE 25	37.098	38.902	41.314	43.686	41.144	37.856	39.651	47.349
			26-55	23.338	59.662	37.655	57.345	25.528	41.472	32.100	46.900
			GE 56	7.000	4.000	4.647	12.353	3.397	8.603	3.638	6.362
MORE THAN 1	OTHER	MALE	LE 25	61.517	111.483	107.260	180.739	130.703	196.296	228.721	389.269
			26-55	58.871	140.129	65.092	156.908	79.212	234.788	124.003	319.991
			GE 56	15.235	83.765	32.357	83.643	35.546	142.454	51.776	154.224
		FEMALE	LE 25	41.000	44.000	49.064	56.936	75.061	85.939	78.263	102.736
			26-55	23.208	77.792	39.801	71.198	59.401	111.599	50.194	120.806
			GE 56	7.000	17.000	22.837	31.163	17.506	65.494	31.461	63.539
	RUSH	MALE	LE 25	19.701	20.299	25.070	53.930	28.707	49.293	70.309	64.651
			26-55	13.779	33.221	16.209	42.791	19.851	42.149	31.672	64.328
			GE 56	3.255	22.745	7.243	25.757	11.544	32.456	17.375	35.625
		FEMALE	LE 25	16.969	13.031	16.877	20.123	24.077	22.923	24.559	29.441
			26-55	13.356	20.644	14.314	22.686	19.041	43.959	12.534	49.466
			GE 56	2.000	10.000	6.463	6.537	5.000	14.000	6.497	11.503
	LATE	MALE	LE 25	104.361	175.639	207.209	367.783	166.921	270.076	292.405	515.577
			26-55	39.125	126.875	62.968	133.012	47.922	137.078	91.608	166.392
			GE 56	3.255	17.745	4.478	18.522	9.169	24.831	13.383	39.617
		FEMALE	LE 25	43.550	32.450	47.860	56.140	56.791	63.209	47.223	70.777
			26-55	17.401	30.599	17.011	35.989	19.520	38.480	19.132	44.868
			GE 56	1.944	3.056	1.478	6.522	1.000	7.000	4.011	6.989

TABLE 3.1 (CONTINUED). RAW FATAL INVOLVEMENT DATA (FARS, 1977)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	71.416	131.584	110.329	212.670	65.897	126.103	111.583	226.417
			26-55	96.951	222.049	109.660	273.336	86.332	202.668	129.048	265.950
			GE 56	31.148	112.852	50.428	134.571	37.028	109.972	56.003	161.997
		FEMALE	LE 25	43.881	41.119	43.672	58.328	41.207	41.793	41.707	40.292
			26-55	19.177	79.823	51.376	66.624	39.476	67.524	35.361	78.639
			GE 56	15.173	44.827	32.809	48.191	16.026	44.574	24.866	50.133
	RUSH	MALE	LE 25	28.771	56.229	51.098	90.902	31.844	73.156	60.203	95.797
			26-55	39.793	115.207	50.982	110.018	47.452	111.547	60.034	93.966
			GE 56	18.518	37.482	25.380	59.619	8.398	39.602	27.418	68.582
		FEMALE	LE 25	24.653	36.347	21.105	34.895	34.421	28.579	34.831	36.166
			26-55	26.382	56.618	26.638	47.362	31.557	69.443	22.425	46.575
			GE 56	6.707	23.293	10.956	24.044	5.298	27.702	16.937	21.063
	LATE	MALE	LE 25	102.367	149.633	150.202	240.798	91.022	162.978	148.796	266.201
			26-55	78.730	228.269	89.887	237.113	76.739	197.261	88.259	255.741
			GE 56	7.928	35.072	13.246	49.754	5.733	27.267	15.586	36.414
		FEMALE	LE 25	33.000	39.000	43.319	38.681	31.739	32.261	32.017	30.983
			26-55	26.028	45.972	34.259	39.741	27.077	29.923	23.555	30.444
			GE 56	4.000	9.000	3.975	6.025	2.000	9.000	1.769	8.231
MORE THAN 1	OTHER	MALE	LE 25	58.266	89.734	116.600	177.400	98.176	171.823	176.786	294.208
			26-55	61.946	133.054	59.866	150.134	86.535	213.465	66.348	239.651
			GE 56	11.504	64.496	40.109	88.891	42.950	128.049	35.026	125.974
		FEMALE	LE 25	28.520	37.480	35.240	48.760	65.089	61.911	53.839	61.161
			26-55	32.856	56.144	28.895	57.104	56.889	99.111	41.191	55.809
			GE 56	3.584	23.416	22.961	31.039	11.944	42.056	20.606	50.394
	RUSH	MALE	LE 25	11.441	20.559	28.255	43.745	31.605	37.395	54.335	68.665
			26-55	9.644	33.356	10.230	37.770	26.403	54.596	27.959	55.041
			GE 56	5.413	26.587	12.613	13.387	6.167	54.833	16.139	50.861
		FEMALE	LE 25	13.193	8.807	17.177	18.823	31.550	26.450	14.271	20.729
			26-55	12.403	27.597	19.586	20.414	23.347	38.652	19.518	48.482
			GE 56	6.398	9.602	8.426	5.574	4.000	20.000	8.905	16.095
	LATE	MALE	LE 25	107.597	175.403	210.322	328.672	100.080	169.920	225.593	393.398
			26-55	48.778	122.222	62.198	103.802	54.945	134.055	55.485	156.515
			GE 56	5.000	19.000	6.257	26.743	2.000	12.000	7.403	18.597
		FEMALE	LE 25	39.271	33.729	34.593	48.407	35.244	29.756	30.895	32.105
			26-55	17.043	22.957	10.000	23.000	18.014	36.986	11.600	33.400
			GE 56	2.000	2.000	0.000	1.000	2.000	2.000	1.000	5.000

TABLE 3.2 SMOOTHED ESTIMATES OF FATAL INVOLVEMENTS (FARS, 1977)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	66.514	109.146	106.752	169.350	87.730	143.960	137.461	243.855
			26-55	85.625	221.916	107.828	255.591	86.469	224.103	122.176	269.602
			GE 56	24.581	96.419	55.359	146.327	28.584	112.121	61.685	163.047
		FEMALE	LE 25	37.271	43.110	47.923	59.917	46.927	54.279	49.508	61.898
			26-55	39.510	89.848	41.995	87.342	42.061	95.648	42.149	87.663
			GE 56	13.751	42.521	26.785	55.813	18.389	56.864	28.842	60.100
	RUSH	MALE	LE 25	30.281	46.346	48.600	60.402	36.567	55.966	57.303	54.801
			26-55	37.775	91.315	47.571	105.172	34.926	84.427	49.349	109.103
			GE 56	10.500	38.417	23.648	58.302	11.179	40.900	24.125	59.477
		FEMALE	LE 25	19.695	21.470	25.324	29.840	22.703	24.749	23.952	28.223
			26-55	22.549	48.328	23.967	46.980	21.978	47.103	22.024	43.171
			GE 56	5.446	15.873	10.609	20.835	6.669	19.435	10.459	20.541
	LATE	MALE	LE 25	98.890	163.413	158.714	283.492	122.250	202.014	191.579	342.194
			26-55	87.445	228.225	110.120	262.858	82.768	216.016	116.947	279.152
			GE 56	7.391	29.197	16.647	44.309	6.056	31.822	17.385	46.275
		FEMALE	LE 25	35.523	34.785	45.676	48.346	41.921	41.050	44.226	46.812
			26-55	27.796	53.513	29.544	52.020	27.734	53.353	27.792	48.936
			GE 56	2.743	7.180	5.342	9.424	3.438	8.999	5.392	9.511
MORE THAN 1	OTHER	MALE	LE 25	56.971	93.486	108.584	192.599	122.098	200.356	227.225	403.036
			26-55	54.186	140.434	66.604	157.876	88.913	230.438	122.625	290.666
			GE 56	18.946	74.315	32.148	84.974	35.797	140.417	58.205	153.851
		FEMALE	LE 25	37.332	43.180	46.187	57.746	76.376	88.341	77.530	96.932
			26-55	31.594	71.847	35.413	73.652	54.651	124.278	57.753	120.117
			GE 56	8.182	25.300	16.949	35.318	17.779	54.977	29.656	61.795
	RUSH	MALE	LE 25	14.890	22.790	28.380	46.951	29.777	45.575	55.416	91.678
			26-55	13.627	32.940	16.750	37.031	20.864	50.435	28.775	63.617
			GE 56	5.754	21.050	9.763	24.069	10.144	37.113	16.494	40.663
		FEMALE	LE 25	12.270	13.376	15.181	17.888	23.424	25.535	23.778	28.018
			26-55	11.136	23.867	12.482	24.467	17.974	38.523	18.995	37.233
			GE 56	2.496	7.274	5.171	10.155	5.061	14.750	8.442	16.579
	LATE	MALE	LE 25	108.808	179.801	207.383	370.424	162.353	268.282	302.140	539.677
			26-55	49.535	129.283	60.888	145.340	56.590	147.696	78.047	186.298
			GE 56	4.871	19.240	8.265	22.000	6.407	25.310	10.418	27.731
		FEMALE	LE 25	39.767	38.941	49.199	52.076	56.643	55.466	57.498	60.860
			26-55	17.310	33.326	19.402	34.163	20.847	40.134	22.030	38.790
			GE 56	1.214	3.178	2.515	4.436	1.836	4.807	3.063	5.404

TABLE 3.2 (CONTINUED). SMOOTHED ESTIMATES OF FATAL INVOLVEMENTS (FARS, 1977)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
OCCUPANTS	TIME	SEX	VEHICLE WEIGHT: AGE	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
ONE	OTHER	MALE	LE 25	74.191	121.743	111.722	198.164	78.295	126.478	115.121	204.155
			26-55	91.273	236.554	107.844	255.630	66.076	223.085	114.113	270.450
			GE 56	27.489	107.827	58.087	153.537	27.874	109.338	56.440	149.185
		FEMALE	LE 25	37.840	43.768	45.652	57.076	38.121	44.053	37.734	47.177
			26-55	38.335	87.176	38.231	79.513	38.111	86.665	35.833	74.527
			GE 56	13.997	43.282	25.581	53.305	16.323	50.475	24.021	50.053
	RUSH	MALE	LE 25	34.519	52.832	51.981	85.997	39.367	60.252	57.684	55.761
			26-55	41.153	99.480	48.625	107.503	41.941	101.384	55.602	122.927
			GE 56	12.001	43.907	25.360	62.521	13.151	48.114	26.628	65.649
		FEMALE	LE 25	24.321	26.513	29.342	34.574	26.478	28.664	26.209	30.883
			26-55	26.612	57.035	26.539	52.021	28.590	61.274	26.881	52.692
			GE 56	6.743	19.653	12.324	24.203	8.498	24.767	12.506	24.560
	LATE	MALE	LE 25	101.681	168.024	153.118	273.496	99.355	164.179	146.087	260.937
			26-55	85.926	224.261	101.527	242.346	75.030	195.821	99.469	237.433
			GE 56	7.620	30.099	16.101	42.858	7.154	28.259	14.486	38.558
		FEMALE	LE 25	32.551	31.875	39.270	41.566	30.362	29.732	30.054	31.612
			26-55	24.341	46.861	24.274	42.742	22.405	43.135	21.067	37.093
			GE 56	2.520	6.596	4.605	8.124	2.721	7.122	4.004	7.063
MORE THAN 1	OTHER	MALE	LE 25	58.230	95.552	104.132	184.703	99.851	163.850	174.352	309.253
			26-55	52.928	137.174	61.041	144.691	81.105	210.201	104.951	248.772
			GE 56	19.415	76.155	30.910	81.702	31.989	125.477	48.802	128.994
		FEMALE	LE 25	34.731	40.172	40.317	50.406	56.853	65.759	54.148	67.700
			26-55	28.090	63.879	29.541	61.441	45.376	103.187	44.992	93.574
			GE 56	7.631	23.599	14.833	30.909	14.461	44.717	22.632	47.160
	RUSH	MALE	LE 25	15.554	23.806	27.815	46.017	29.376	44.960	51.294	84.859
			26-55	13.603	32.883	15.688	34.685	22.958	55.498	29.709	65.681
			GE 56	6.026	22.046	9.594	23.652	10.935	40.007	16.682	41.128
		FEMALE	LE 25	13.885	15.136	16.118	18.992	25.033	27.289	23.843	28.094
			26-55	12.043	25.811	12.665	24.826	21.426	45.920	21.244	41.643
			GE 56	2.832	8.253	5.504	10.810	5.910	17.224	9.250	18.165
	LATE	MALE	LE 25	102.519	169.409	183.333	327.467	120.908	199.756	211.120	377.099
			26-55	44.603	116.410	51.440	122.789	47.008	122.687	60.829	145.200
			GE 56	4.601	18.175	7.326	19.499	5.214	20.596	7.955	21.173
		FEMALE	LE 25	33.391	32.698	38.761	41.027	37.593	36.812	35.805	37.859
			26-55	13.891	26.742	14.608	25.722	15.433	29.711	15.302	26.943
			GE 56	1.022	2.675	1.986	3.504	1.332	3.466	2.084	3.677

TABLE 3.3 RAW VEHICLE MILES TRAVELED DATA (NPTS, 1977)
(BILLIONS)

SEASON: SUMMER

		LAND USE:		URBAN				RURAL			
		VEHICLE AGE:		5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
		VEHICLE WEIGHT:		LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	1.84262	2.04144	2.03699	2.05334	0.57446	0.83566	1.06864	1.45761
			26-55	3.77420	8.93948	3.45336	6.74745	1.15501	4.40085	0.87766	2.80156
			GE 56	0.44054	1.79268	0.57979	2.38673	0.22577	1.45552	0.18141	1.54160
		FEMALE	LE 25	2.23281	1.59040	1.36129	1.29208	0.85604	1.12303	0.70998	0.78918
			26-55	2.23048	5.16503	2.79431	4.21692	1.22568	1.94979	0.44067	2.24952
			GE 56	0.48610	1.46152	0.36562	1.21292	0.21838	1.22870	0.36146	0.57517
	RUSH	MALE	LE 25	1.23908	2.36020	1.25920	2.14463	0.65497	0.90713	0.43359	1.26054
			26-55	4.15340	9.99192	3.78793	7.35671	2.01465	3.95698	1.41528	2.50379
			GE 56	0.48054	1.27851	0.62030	1.53229	0.32747	0.41060	0.20600	0.56940
		FEMALE	LE 25	1.91871	1.51322	1.11924	0.99061	0.74165	0.85887	0.50122	0.34133
			26-55	2.59372	4.61329	2.37577	3.67971	0.83698	1.55493	0.50989	1.45886
			GE 56	0.31259	0.92735	0.30590	0.74757	0.16024	0.65618	0.07966	0.23615
	LATE	MALE	LE 25	0.54600	1.02183	0.76144	0.97539	0.31345	0.22310	0.34224	0.35113
			26-55	0.66202	2.58897	0.89853	1.43447	0.33143	1.00917	0.25553	0.58320
			GE 56	0.02198	0.21068	0.07435	0.37230	0.01085	0.03577	0.00364	0.12434
		FEMALE	LE 25	0.44829	0.19942	0.20782	0.27835	0.10593	0.15312	0.09660	0.12817
			26-55	0.39513	0.62809	0.34308	0.49953	0.08288	0.30336	0.03645	0.31572
			GE 56	0.19765	0.28837	0.01831	0.15692	0.01143	0.08615	0.00534	0.01889
MORE THAN 1	OTHER	MALE	LE 25	1.99856	2.11794	1.60051	2.14836	1.63273	1.24046	1.17520	1.85059
			26-55	4.10864	10.21565	2.50361	6.98186	3.01745	10.68858	1.83180	8.50968
			GE 56	0.90240	4.18334	0.40169	2.94934	0.97021	5.32610	0.35598	3.25218
		FEMALE	LE 25	1.96259	1.14089	1.09968	1.29013	1.28928	1.10493	0.76453	0.42866
			26-55	2.01967	6.05934	1.92052	3.94326	0.99589	3.87170	0.75150	3.35674
			GE 56	0.32479	0.60922	0.34187	0.69758	0.27551	1.07206	0.17680	0.67581
	RUSH	MALE	LE 25	0.29863	0.64636	0.64051	0.70449	0.60509	0.55188	0.46050	0.70999
			26-55	1.69477	2.45049	0.82178	2.69691	1.15556	2.44530	0.14639	2.26877
			GE 56	0.44018	0.93769	0.13946	0.52140	0.35019	0.90101	0.07348	0.67650
		FEMALE	LE 25	0.32090	0.59950	0.53575	0.59195	0.21165	0.34780	0.25039	0.22698
			26-55	1.09234	2.07123	0.52442	1.49710	0.45336	1.65384	0.19198	0.95713
			GE 56	0.12944	0.26937	0.06678	0.21869	0.08712	0.15656	0.00230	0.21116
	LATE	MALE	LE 25	0.37252	0.75155	0.33165	0.79020	0.09756	0.28526	0.15187	0.37384
			26-55	0.70129	1.61093	0.64416	1.23115	0.46094	1.37433	0.12575	1.53414
			GE 56	0.03772	0.70539	0.08468	0.17855	0.00432	0.53372	0.01371	0.10339
		FEMALE	LE 25	0.22288	0.19628	0.19743	0.33097	0.07227	0.25163	0.25513	0.09458
			26-55	0.14955	0.66221	0.20968	0.34873	0.03565	0.80670	0.02958	0.43165
			GE 56	0.00976	0.04670	0.04292	0.00229	0.00000	0.05362	0.06822	0.02833

TABLE 3.3 (CONTINUED). RAW VEHICLE MILES TRAVELED DATA (NPTS, 1977)
(BILLIONS)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	2.10696	2.45535	1.60251	2.24207	0.53149	1.06574	0.64476	1.06807
			26-55	4.02035	7.79386	2.93499	5.07446	1.90089	3.40423	1.10259	2.14365
			GE 56	0.95966	2.09873	0.74302	1.77518	0.28976	1.38551	0.25726	1.22560
		FEMALE	LE 25	1.89038	2.04030	1.44944	1.08262	0.90487	0.96852	0.64937	0.55799
			26-55	2.25213	6.48996	1.53324	3.62663	0.61812	3.82440	0.69173	1.75256
			GE 56	0.38318	1.72250	0.40662	0.83687	0.21204	0.55842	0.20520	0.22957
	RUSH	MALE	LE 25	1.69365	2.27168	1.45632	1.84454	0.60274	0.86539	0.43025	0.91131
			26-55	4.33318	8.66729	4.10667	5.79196	1.88477	3.83821	1.83736	2.74122
			GE 56	0.69312	2.12893	0.43790	1.59830	0.12170	0.43083	0.10717	0.44956
		FEMALE	LE 25	1.41572	1.81993	1.18868	1.06600	0.57997	0.43472	0.57802	0.62773
			26-55	2.03897	5.38153	1.73719	3.17102	0.63195	3.12406	0.58602	1.33834
			GE 56	0.26014	0.67935	0.29951	0.77461	0.02995	0.45267	0.13043	0.26701
	LATE	MALE	LE 25	0.95229	0.74594	0.37939	0.72712	0.37617	0.37524	0.17362	0.37394
			26-55	0.87849	1.88961	0.75380	1.85067	0.30364	0.94356	0.52008	0.96140
			GE 56	0.06225	0.44566	0.30211	0.30743	0.01141	0.16851	0.00140	0.06997
		FEMALE	LE 25	0.30579	0.38451	0.34336	0.31315	0.25935	0.04001	0.06985	0.05901
			26-55	0.30535	0.91816	0.28966	0.51248	0.20166	0.56267	0.18363	0.31206
			GE 56	0.00953	0.18116	0.02476	0.03988	0.03115	0.03170	0.00870	0.04218
MORE THAN 1	OTHER	MALE	LE 25	2.06721	1.59128	1.14265	1.62442	2.08727	1.48365	0.46224	1.45035
			26-55	3.42885	9.33051	1.52537	5.33135	3.33617	9.11647	1.11377	6.40549
			GE 56	0.80985	3.05356	0.85210	1.54281	0.29980	3.97792	0.48908	1.98400
		FEMALE	LE 25	0.78968	0.73257	0.56649	0.84163	0.58801	1.03035	0.22017	0.74525
			26-55	1.85145	4.92445	1.40770	3.06707	0.87786	4.57268	0.80838	2.01515
			GE 56	0.11070	0.57992	0.09338	0.47390	0.50142	0.47060	0.02164	0.36856
	RUSH	MALE	LE 25	0.51568	0.68069	0.34983	0.65040	0.19717	0.57066	0.16385	0.15837
			26-55	1.68602	2.75228	0.75597	2.27246	1.32407	1.82602	0.46131	1.51233
			GE 56	0.19623	0.89589	0.19676	0.37939	0.07626	1.25391	0.07734	0.21328
		FEMALE	LE 25	0.28768	0.62755	0.24652	0.51292	0.43801	0.26747	0.07851	0.15567
			26-55	0.82315	2.08916	0.52980	1.51877	0.66756	1.61851	0.31327	0.90810
			GE 56	0.08154	0.15954	0.02994	0.12238	0.04658	0.10868	0.00327	0.01738
	LATE	MALE	LE 25	0.36873	0.78705	0.29123	0.63782	0.30489	0.61113	0.11782	0.32039
			26-55	0.76259	1.56831	0.29311	0.80720	0.28012	0.82256	0.36608	0.57557
			GE 56	0.17173	0.21558	0.12356	0.15610	0.03845	0.16976	0.04370	0.01464
		FEMALE	LE 25	0.13910	0.28164	0.06692	0.12139	0.17470	0.19608	0.05356	0.03240
			26-55	0.17975	0.48954	0.03298	0.21691	0.16158	0.37450	0.02821	0.10506
			GE 56	0.01319	0.03437	0.00575	0.00278	0.00000	0.00677	0.00000	0.00040

TABLE 3.4 SMOOTHED ESTIMATES OF VEHICLE MILES TRAVELED (NPTS, 1977)
(BILLIONS)

SEASON: SUMMER

		LAND USE:		URBAN				RURAL			
		VEHICLE AGE:		5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
		VEHICLE WEIGHT:		LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	1.78806	2.03631	1.74624	2.07214	0.75358	0.84755	0.87114	1.15331
			26-55	3.45758	8.75094	3.18540	6.82341	1.37911	4.01655	1.10669	3.16863
			GE 56	0.52488	1.99762	0.70397	2.08759	0.21966	1.31772	0.24703	1.34971
		FEMALE	LE 25	2.16303	1.73511	1.69469	1.18720	1.04974	0.86247	0.84114	0.70545
			26-55	2.25046	5.39749	2.37307	4.03739	0.80483	2.72269	0.63870	1.79169
			GE 56	0.49098	1.57239	0.53781	1.12482	0.36521	1.06670	0.26983	0.64620
	RUSH	MALE	LE 25	1.53861	2.22796	1.50262	2.26716	0.57085	0.81635	0.65990	1.14938
			26-55	4.36392	9.10960	4.02040	7.10307	1.53580	3.68916	1.23242	2.92872
			GE 56	0.47123	1.54250	0.63202	1.61197	0.14122	0.72864	0.15882	0.74633
		FEMALE	LE 25	1.54937	1.58029	1.21390	1.08127	0.66194	0.69151	0.53040	0.56562
			26-55	2.36441	4.67718	2.49323	3.45859	0.74608	2.08166	0.59208	1.36988
			GE 56	0.36693	1.01070	0.40193	0.72301	0.19545	0.49100	0.15511	0.29744
	LATE	MALE	LE 25	0.63470	0.92046	0.61985	0.93665	0.21630	0.30980	0.25005	0.43618
			26-55	0.88910	2.23072	0.81911	1.73937	0.33076	0.95495	0.26543	0.75811
			GE 56	0.10258	0.34983	0.13758	0.36559	0.02060	0.11076	0.02317	0.11345
		FEMALE	LE 25	0.42173	0.43080	0.33042	0.29476	0.16550	0.17316	0.13261	0.14163
			26-55	0.31786	0.75574	0.33518	0.56530	0.10603	0.35559	0.08414	0.23358
			GE 56	0.05271	0.15125	0.05773	0.10820	0.01882	0.04925	0.01453	0.02963
MORE THAN 1	OTHER	MALE	LE 25	1.83996	2.16928	1.45884	2.50996	1.64103	1.91075	0.95866	1.90403
			26-55	4.08038	10.69129	2.50953	7.79423	3.22721	9.73033	1.86697	7.88290
			GE 56	0.95519	3.76346	0.58792	2.52783	0.91253	5.66727	0.41253	3.26800
		FEMALE	LE 25	1.45806	1.21084	1.19942	1.21828	1.18102	1.00453	0.61847	0.75208
			26-55	2.18788	5.43239	1.61003	3.97161	1.22364	4.28574	0.73965	3.00840
			GE 56	0.24387	0.80855	0.23313	0.70695	0.32660	0.98756	0.19813	0.64049
	RUSH	MALE	LE 25	0.48506	0.72714	0.38458	0.84133	0.36084	0.56384	0.22248	0.56185
			26-55	1.57777	3.40967	0.97037	2.46574	1.10103	2.73803	0.64378	2.21818
			GE 56	0.26272	0.89030	0.16171	0.59800	0.17974	0.96007	0.08125	0.55362
		FEMALE	LE 25	0.49046	0.51788	0.40345	0.52106	0.34973	0.37823	0.18314	0.28317
			26-55	1.07946	2.21061	0.79436	1.61617	0.53268	1.53878	0.32199	1.08016
			GE 56	0.08559	0.24406	0.08182	0.21339	0.08208	0.21347	0.04979	0.13844
	LATE	MALE	LE 25	0.41361	0.62099	0.32794	0.71851	0.29830	0.44230	0.17426	0.44075
			26-55	0.66449	1.72594	0.40868	1.25826	0.49017	1.40508	0.28661	1.16691
			GE 56	0.11822	0.41739	0.07277	0.26035	0.05421	0.30167	0.02451	0.17395
		FEMALE	LE 25	0.22174	0.23449	0.18240	0.23593	0.14524	0.15731	0.07606	0.11777
			26-55	0.24104	0.59328	0.17738	0.43375	0.12573	0.43655	0.07600	0.30644
			GE 56	0.02042	0.06067	0.01952	0.05304	0.01313	0.03556	0.00796	0.02306

TABLE 3.4 (CONTINUED). SMOOTHED ESTIMATES OF VEHICLE MILES TRAVELLED (NPTS, 1977) (BILLIONS)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	2.14317	2.13212	1.74962	1.81385	0.87368	0.85839	0.84436	1.01038
			26-55	3.82019	8.44618	2.94233	5.50582	1.67253	4.25521	1.12206	2.82414
			GE 56	0.66235	2.20206	0.74267	1.92387	0.22198	1.16328	0.20871	0.95612
		FEMALE	LE 25	1.97294	1.88158	1.29227	1.07630	0.92615	0.90467	0.62042	0.61663
			26-55	2.16389	6.17024	1.90761	3.85857	0.84944	3.41667	0.56356	1.87953
			GE 56	0.37928	1.44410	0.34733	0.86364	0.22593	0.78455	0.14990	0.35734
	RUSH	MALE	LE 25	1.84418	2.33279	1.50570	1.98456	0.66183	0.82679	0.63962	0.97319
			26-55	4.82158	8.79235	3.71361	5.73147	1.86255	3.90836	1.24954	2.55394
			GE 56	0.59465	1.70037	0.66676	1.46556	0.14271	0.64324	0.13418	0.55081
		FEMALE	LE 25	1.41321	1.71370	0.92565	0.98027	0.58401	0.72535	0.39122	0.45601
			26-55	2.27345	5.34680	2.00420	3.34363	0.78743	2.61230	0.52242	1.43705
			GE 56	0.28345	0.92824	0.25957	0.55513	0.12091	0.36112	0.08022	0.16289
	LATE	MALE	LE 25	0.76075	0.96377	0.62112	0.81990	0.25078	0.31376	0.24236	0.36932
			26-55	0.98235	2.15304	0.75661	1.40350	0.40114	1.01170	0.26911	0.67145
			GE 56	0.12945	0.38564	0.14515	0.33692	0.02082	0.09778	0.01958	0.06373
		FEMALE	LE 25	0.38467	0.46717	0.25196	0.26723	0.14602	0.18163	0.09782	0.12420
			26-55	0.30564	0.86394	0.26944	0.54026	0.11190	0.44619	0.07424	0.24545
			GE 56	0.04072	0.13891	0.03729	0.08307	0.01164	0.03622	0.00772	0.01834
MORE THAN 1	OTHER	MALE	LE 25	1.81387	1.86813	1.20232	1.80706	1.50483	1.59165	0.76424	1.32556
			26-55	3.70797	8.48709	1.90653	5.17269	3.21902	8.47848	1.57354	5.74238
			GE 56	0.99137	3.41214	0.51013	1.91603	0.75847	4.11467	0.26665	1.98372
		FEMALE	LE 25	1.09383	1.07995	0.75224	0.90841	0.65700	0.86663	0.37520	0.54244
			26-55	1.73025	5.10768	1.06447	3.12186	1.06219	4.42304	0.53678	2.55565
			GE 56	0.15494	0.61076	0.12383	0.44644	0.16618	0.59740	0.08428	0.32391
	RUSH	MALE	LE 25	0.47818	0.62619	0.31696	0.60572	0.36316	0.46967	0.17736	0.35127
			26-55	1.43376	2.70671	0.73720	1.64968	1.09823	2.38577	0.53684	1.61586
			GE 56	0.27268	0.80719	0.14031	0.45327	0.14939	0.69708	0.05646	0.33605
		FEMALE	LE 25	0.36794	0.46190	0.25304	0.38853	0.25378	0.32630	0.11110	0.20424
			26-55	0.85367	2.07848	0.52519	1.27039	0.46240	1.58808	0.23367	0.93196
			GE 56	0.05438	0.18436	0.04346	0.13476	0.04176	0.12913	0.02118	0.07002
	LATE	MALE	LE 25	0.40775	0.53478	0.27028	0.51729	0.28445	0.36844	0.13892	0.30694
			26-55	0.60384	1.37010	0.31048	0.83505	0.48893	1.27659	0.23900	0.86462
			GE 56	0.12270	0.37843	0.06314	0.21250	0.04506	0.21903	0.01703	0.10559
		FEMALE	LE 25	0.16635	0.20914	0.11440	0.17592	0.10539	0.13572	0.04614	0.06454
			26-55	0.19062	0.55782	0.11727	0.34095	0.10914	0.45054	0.05516	0.26440
			GE 56	0.01297	0.04582	0.01037	0.03350	0.00668	0.02151	0.00339	0.01166

TABLE 3.5 FATAL INVOLVEMENT RATES (SMOOTHED FARS ÷ SMOOTHED NPTS, 1977)
(FATAL INVOLVEMENTS PER BILLION VMT)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	37.20	53.60	61.13	91.38	116.42	169.65	157.62	204.35
			26-55	24.76	25.36	33.85	37.46	62.70	55.80	110.40	90.82
			GE 56	46.83	48.27	78.64	70.09	130.14	85.09	249.70	120.80
		FEMALE	LE 25	17.23	24.85	26.28	50.47	44.70	62.93	58.86	87.74
			26-55	17.56	16.65	17.70	21.63	52.26	35.13	65.99	46.93
			GE 56	28.01	27.04	49.80	49.62	50.35	53.31	95.51	93.01
	RUSH	MALE	LE 25	19.68	20.80	32.34	35.46	64.06	68.56	86.83	82.48
			26-55	8.66	10.02	11.83	14.81	22.74	22.68	40.04	37.25
			GE 56	22.28	24.91	37.42	36.17	79.17	56.13	151.90	79.69
		FEMALE	LE 25	12.71	13.59	20.66	27.60	34.30	35.79	45.16	49.90
			26-55	9.54	10.33	9.61	13.43	29.46	22.63	37.20	31.51
			GE 56	14.84	15.70	26.39	26.82	34.12	39.58	67.42	69.06
	LATE	MALE	LE 25	155.81	177.53	256.05	302.67	565.17	652.09	766.15	784.54
			26-55	98.35	102.31	134.44	151.12	250.25	226.20	440.62	368.21
			GE 56	72.05	83.47	120.98	121.20	391.26	287.35	750.71	407.90
		FEMALE	LE 25	84.23	80.74	138.23	164.02	253.32	237.08	333.54	330.47
			26-55	87.45	70.81	86.14	92.02	261.61	150.14	330.22	209.16
			GE 56	52.04	47.47	92.49	87.12	182.55	182.74	361.56	316.88
MORE THAN 1	OTHER	MALE	LE 25	30.96	43.09	74.43	76.73	74.40	104.86	237.02	211.68
			26-55	13.28	13.13	26.54	20.25	27.55	23.68	64.98	36.87
			GE 56	19.84	19.75	54.68	33.62	39.23	24.78	141.10	47.08
		FEMALE	LE 25	25.60	35.66	38.51	47.40	64.67	87.94	125.36	126.68
			26-55	14.44	13.23	22.00	18.55	44.66	29.00	78.08	35.93
			GE 56	33.55	31.29	72.69	49.96	54.44	55.67	149.66	96.48
	RUSH	MALE	LE 25	30.70	31.34	73.79	55.81	78.19	80.83	249.08	163.18
			26-55	8.64	9.66	17.26	14.90	18.95	18.42	44.70	26.68
			GE 56	21.90	23.64	60.38	40.25	56.44	38.66	203.04	73.45
		FEMALE	LE 25	25.02	25.83	37.63	34.33	66.98	67.51	129.63	96.55
			26-55	10.32	10.80	15.71	15.14	33.74	25.04	58.99	34.47
			GE 56	29.16	29.80	63.20	47.59	61.65	69.10	169.57	119.74
	LATE	MALE	LE 25	263.08	289.54	632.36	515.56	544.25	606.56	1733.74	1224.53
			26-55	74.55	74.90	148.98	115.51	115.44	100.61	272.33	156.96
			GE 56	41.20	46.10	113.59	78.48	118.21	83.91	425.06	155.41
		FEMALE	LE 25	179.36	166.05	269.76	220.71	390.07	352.54	756.03	516.76
			26-55	71.81	56.17	109.38	78.76	165.78	91.94	289.64	126.57
			GE 56	59.48	52.40	128.92	83.65	140.04	135.23	384.09	234.26

TABLE 3.5 (CONTINUED). FATAL INVOLVEMENT RATES (SMOOTHED FARS ÷ SMOOTHED NPTS, 1977)
(FATAL INVOLVEMENTS PER BILLION VMT)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	34.62	57.10	63.85	105.25	89.61	149.67	136.34	202.10
			26-55	23.89	28.01	36.65	46.43	51.47	52.43	101.70	95.78
			GE 56	41.50	48.97	78.21	79.81	125.57	93.59	270.44	145.77
		FEMALE	LE 25	19.18	23.26	35.33	53.03	41.16	48.74	60.82	76.26
			26-55	17.72	14.13	20.04	20.61	44.87	25.37	63.59	35.65
			GE 56	36.90	29.97	73.65	61.72	72.26	64.34	160.25	125.97
	RUSH	MALE	LE 25	18.72	22.65	34.52	43.33	59.48	72.87	96.49	96.40
			26-55	8.53	11.31	13.09	18.76	22.52	25.94	44.50	47.39
			GE 56	20.18	25.82	38.03	42.08	52.14	74.80	198.46	115.19
		FEMALE	LE 25	17.21	15.47	31.70	35.27	45.34	39.79	66.99	62.26
			26-55	11.71	10.67	13.24	15.56	36.31	23.46	51.46	36.67
			GE 56	23.79	21.17	47.48	43.60	70.27	68.59	155.94	134.30
	LATE	MALE	LE 25	133.66	174.34	246.52	333.57	396.19	523.26	602.80	706.55
			26-55	87.47	104.16	134.19	172.67	187.05	193.56	369.62	353.61
			GE 56	58.85	78.05	110.92	127.21	343.69	289.04	739.13	460.61
		FEMALE	LE 25	84.62	68.23	155.87	155.55	207.93	163.71	307.26	256.10
			26-55	79.64	54.24	90.10	79.12	200.20	96.67	283.73	151.12
			GE 56	61.87	47.49	123.44	97.78	234.08	196.61	519.71	385.17
MORE THAN 1	OTHER	MALE	LE 25	32.10	51.15	86.61	102.21	63.81	102.94	226.13	233.23
			26-55	14.27	16.16	32.02	27.97	25.20	24.79	66.70	43.32
			GE 56	19.58	22.32	60.59	42.64	42.18	30.49	170.26	65.03
		FEMALE	LE 25	31.75	37.20	53.60	55.49	66.34	75.88	144.31	124.60
			26-55	16.23	12.51	27.75	19.68	42.72	23.33	83.82	36.05
			GE 56	49.25	36.64	119.76	69.23	87.03	74.66	268.48	145.60
	RUSH	MALE	LE 25	32.53	38.02	87.76	75.97	60.89	95.72	289.18	216.89
			26-55	9.49	12.15	21.28	21.03	20.90	23.26	55.34	40.65
			GE 56	22.10	27.31	68.38	52.18	73.19	57.39	295.50	122.38
		FEMALE	LE 25	37.74	32.77	63.70	48.88	98.64	83.62	214.60	137.56
			26-55	14.11	12.42	24.12	19.54	46.34	28.91	90.92	44.68
			GE 56	52.08	44.76	126.59	80.22	141.50	133.39	436.82	255.44
	LATE	MALE	LE 25	251.43	316.77	678.30	633.01	425.09	542.25	1519.91	1226.51
			26-55	73.87	84.96	165.68	147.05	96.14	96.11	254.50	167.93
			GE 56	37.49	46.03	115.98	91.77	115.73	94.04	467.10	200.49
		FEMALE	LE 25	200.74	156.34	338.84	233.19	356.73	271.27	776.08	446.25
			26-55	72.87	47.94	124.56	75.45	141.43	65.94	277.48	101.91
			GE 56	78.76	58.38	191.65	104.67	199.76	162.21	616.73	315.11

4.0 VARIANCE ESTIMATES

Sampling variance remains after the log-linear modelling smoothing process. In order to make judgments or decisions based on the smoothed fatal involvement rate data, it is necessary to have estimates of this inaccuracy. A sampling variance is needed for each (smoothed) cell estimate in both the FARS and NPTS matrices and from these a sampling variance can be estimated for each cell for the ratio (fatal involvements per VMT).

These variances are for cell estimates based on log-linear models. As these quantities are the result of highly complex interactive and non-linear transformations of the original data, it is difficult to estimate their variances. In the case of NPTS, the job is made even more difficult because of the complex stratified multistage cluster sampling plan on which it is based.

These problems are overcome by "computer intensive" resampling methods such as the jackknife, the bootstrap or half sampling procedures (see Reference 3 for a general discussion). The methods used for this project were of the half sampling type. The basic principles of using half samples for variance calculations will be descibed first very briefly and then some of the specifics of the FARS and NPTS cases will be dealt with.

4.1 Variance Calculations Using Half Sample Techniques

A large sample can be split into half samples (two mutually exclusive and exhaustive sub-samples) in very many different ways. For example, a sample of 1000 individuals can be split into exactly equal half samples in over 10^{300} ways. The theory of sample splitting techniques (such as jackknife, bootstrap, and half sampling) establishes that the sampling variance of a sample determined quantity can be estimated from its variance over a limited random sample of appropriately determined half samples. (Note that only one half of the sample pair consisting of the half sample and its complement might be used in a given variance calculation.)

Basically, the procedure for estimating the cell variance consists of the following steps:

1. Form N half samples using appropriate procedures.* Appropriate procedures for the FARS and NPTS cases are outlined below.

2. Determine an estimate for each parameter (for which a variance is desired) on each of the N half samples. In the present case the parameters of interest will be the cell estimates determined by a log-linear model. This will consequently involve fitting the log-linear model to each half sample.

3. Determine the variance of each parameter over the N half samples. If the parameter is scaled to be sample size invariant** then this variance will be a good estimate of the variance of the parameter as estimated from the whole sample, i.e. its sampling variance.

These considerations lead to useful variance estimates in the present context. The accuracy of the estimate is limited primarily by how many half samples are used. The technique is "computer intensive" and can be quite costly if too many half samples are used. A reasonable trade-off between cost and accuracy can be made, however.

The considerations in the trade-off are the following:

1. The number of half samples, N, is essentially equivalent, from the point of veiw of accuracy, to the degrees of freedom in an ordinary variance estimate.

*The procedures to be used will result in half samples which are approximately half the size of the full sample.

**In the case of a quantity, such as a cell estimate, which is not sample size invariant but proportional to sample size, multiply the half sample estimated variance by 4 (2^2) to scale to a valid variance for a full-sized sample.

2. A complete model estimation procedure (in the present case the fitting of a complex log- linear model) must be performed on each of the N half samples.

It is well known that if the sample size is greater than about 30, then the confidence interval based on a variance from that sample is only slightly wider than if the variance were based on an infinitely large sample. A 75 percent confidence interval based on a sample of size 20 is about 6 percent wider than one based on an infinite sample. This is probably adequate in most cases. Since the calculation of the variance using 20 half samples is quite feasible, the use of 20 half samples for variance determination is reasonable.

4.2 Construction of Half Samples for the FARS Data

As previously noted, the FARS data used consisted of a matrix of counts of fatal accident involvements by driver, vehicle and environmental characteristics. As noted in Appendix C, it is usual in log-linear modelling to assume that the cell counts can be considered to be independently and Poisson distributed. Both these conditions are violated to some extent by the nature of accident involvement data but the data are treated in this study as if they have the required properties. This assumption is discussed in Appendix C. Based on this assumption, the following method for producing half samples will lead to valid variance estimates for the FARS case.

For each cell, i, in the fatal involvement matrix M_i (i = 1, ..., 576) form a random number binomially distributed with $n = M_i$ and $p = q = \frac{1}{2}$. Denote this number by X_{1i} and repeat the process N times forming X_{2i}..., X_{3i}..., X_{Ni}. The numbers X_{ji} i = 1,..., 576 then form the jth the half sample.*

*A justification for this procedure for developing half samples procedes along the following lines: If the underlying population giving rise to the FARS data could be divided (say spatially or temporally) into two subsets identical in the statistical properties of the accident involvements they generate, then assuming each FARS cell count is Poisson distributed, the distribution of each total cell over each of the two halves would be binimonial as described. The half samples generated as described in the text are thus statistically identical (under the independence and Poisson assumptions) to those that would be generated by half populations.

Using N = 20 half samples, the sampling variance of cell estimates can then be calculated in the manner indicated in Section 4.1.

4.3 Construction of Half Samples for the NPTS Data

The preferred sample splitting technique for constructing variances for samples taken according to complex statistical designs is based on the use of repeated replications* for constructing the required half samples. This technique is useful when there are many strata (say 30) in the sampling scheme. It is described in References 3, 4, and 5.

The procedure calls for dividing the observations in each stratum into two "half-strata" in such a way that each "half-stratum" has the same sampling characteristics as the whole stratum. Among other things, this means that clusters in the whole stratum are not split in developing "half-strata" and as a consequence the "half-strata" may not contain precisely half of the observations from the whole stratum.

Once a set of half strata has been constructed, one pair of half strata for each stratum, the half samples are constructed as follows. The half strata for each stratum are labelled "1" and "2" arbitrarily. Then for each half sample to be constructed a specification of "1" or "2" for each stratum is given and the half sample is constructed by including the designated half from each stratum. This procedure is repeated for each half sample needed. The list of "1's" and "2's" needed for the construction of each half sample can be generated randomly (with each selection being made independently with equal probabilities for "1" and "2") or according to the principles of "balanced repeated replications" or "partially balanced repeated replications." These matters are discussed in Appendix E where it is concluded that a random choice for each half stratum designation is adequate and is to be preferred for simplicity.

*The term "pseudo replications" also applies. The term "balanced repeated replications" refers to a special case of repeated replications and will be mentioned below and discussed in Appendix E.

In the case of the NPTS data there are two types of strata: self-representing (SR) and non-self-representing (NSR).* The SR strata are handled in the standard manner (i.e. split into two half strata preserving the clusters intact, etc.) but the NSR strata are paired into pseudo strata. Thus, each half stratum is either half of the sample from a SR Primary Sampling Unit (PSU) or the whole sample from one of a pair of NSR PSU's. The two half strata may be said to comprise a pseudo stratum whether it is an actual stratum (SR PSU) or a pseudo stratum (represented by a pair of NSR PSU's).

As there are 156 SR strata and 220 NSR strata in the NPTS data there are (ideally) 156 + 220/2 = 266 pseudo strata (PSU's) for the purpose of selecting half sample replications. (A different number of pseudo strata was actually used as will be explained below.)

A designation of what part of the sample each household serial number comes from is not part of the NPTS user tapes. For this project the Bureau of the Census decided to provide directly a designation of a numbered pseudo stratum and half stratum for each household serial number. The numbered pseudo strata were not identified geographically in keeping with the policy of restricting information which might affect privacy. This privacy consideration limited the amount of information supplied (as opposed to identifying clusters, etc. in order to permit half stratum construction) while providing the necessary information for the construction of balanced repeated replications. Further limiting the information supplied, Census determined that even to designate a numbered pseudo stratum and half stratum would violate their privacy restrictions in the case of 14 PSU's. Consequently, these strata were all lumped together into one psuedo stratum. Census estimated that this lumping would lead to underestimating the variance by 2 to 3 percent. This seems to be a high estimate of the error since the lumped pseudo stratum in question accounted for

*A self-representing stratum coincides with an important PSU. A non-self-representing stratum consists of several PSU's represented by one PSU. The half samples are constructed using trip records derived from the NPTS data. The basic requirement is a knowledge of which stratum and half stratum each trip record (as identified by household serial number) belongs to.

only 2.6 percent of the total number of households. Such a small effect on the variance is quite acceptable for the present needs.

The tape from Census listed all the household serial numbers in the NPTS sample and for each gave a pseudo stratum number from 1 to 253 (266 - 14 + 1) and a half stratum designation of 1 or 2. This enabled the half samples to be constructed in the manner outlined previously in this section.

4.4 Final Calculations of Variance and Results

Once the set of half samples has been constructed, the actual variance calculation is the same for the FARS and NPTS cases. The procedure is as follows: fit the model as finally specified for the given data set (FARS or NPTS) to each half sample. Form the variance of the (smoothed) cell estimate for each cell over the collection of half samples and multiply the variance by four (since cell estimates are not sample size invariant).

A relative variance is then constructed by dividing by the square of the corresponding cell estimate. Once the relative cell variance for the FARS and NPTS cell estimates are constructed, the relative variance for their ratio is easily estimated by taking the sum of the FARS and NPTS relative variances for the cell in question. Approximate 95% intervals are constructed using relative variances as follows:

$X_E e^{-2\sigma} \leq X_T \leq e^{2\sigma} X_E$ where X_T is the true value X_E the estimated value and σ the square root of the corresponding relative variance.*

*Since these relative variances were calculated (originally) by dividing a regular variance by the square of a mean value, they underestimate the variance of the logarithm slightly. This bias ranges from negligible ($<1\%$) when $\sigma = .25$ (usual case) to approximately 6% when $\sigma = .6$ (worst case). Thus the confidence interval is at most 6% in error (due to this effect) and usually much less.

Table 4.1 gives the relative standard errors* for use with the FARS cell estimates while Table 4.2 gives the corresponding values for the NPTS cell estimates and Table 4.3 gives the relative standard errors for the ratios (fatal involvement rates). (Tables 4.1, 4.2 and 4.3 give relative standard errors corresponding to Tables 3.2, 3.4 and 3.5 respectively.)

The use of these Tables is illustrated by calculating a confidence interval for a fatal involvement rate using Table 3.5 and Table 4.3. The fatal involvement rate for males, 25 years old or less, on urban roads, in light cars, less than 5 years old, alone in the car, during the "other" time period (i.e. not late night or rush hour) in the "summer" season is estimated by the top left entry in Table 3.5, i.e. 37.2 fatal involvements per billion VMT. The corresponding estimated relative standard error is .142418. Thus, the 95 percent confidence interval for the true value of this fatal invovlement rate is

$$37.2e^{-2 \times .142} \leq R \leq 37.2e^{+2 \times .142} \quad \text{or } 28.0 \leq R \leq 49.4$$

The following comments are based on the tables. First, it will be noted that relative standard errors for the rates are rather large. For example, the upper limit of the confidence interval calculated above, 49.4 is nearly 1.8 times the lower limit, 28.0. This is fairly typical. However, the ratios of fatal involvement rates which are typically found in Table 3.5 are often much larger than two to one (the largest was observed in Section 3.3 to be over 200 to 1). Consequently many comparisons observable in Table 3.5 cannot be ascribed to noise alone. In each case where a comparison of two rates in Table 3.5 is to be made, a relative standard error for the ratio of the rates can be constructed by forming the square root of the sum of the squares of the relative standard errors of the two rates to be compared. This standard error should ideally be corrected by a covariance term. However, in the absence of any explicit estimates of the covariances it is suggested that:

*The relative standard error is the standard error divided by the cell estimate or equivalently, by the last paragraph, the standard error in the logarithm of the cell estimate.

(a) If the cells being compared are near each other (e.g. differ in only one variable) the covariance correction may often reduce the standard error of the ratio.

(b) Even if the covariance correction increases the estimated standard error of the ratio it can never increase it by more than a factor of 1.414 (i.e. $\sqrt{2}$).

An example of these considerations is as follows. The fatal involvement rate in the top left corner of Table 3.5 is 37.2 while the rate in the top right corner is 204.35; the ratio of these is 204.35/37.2 = 5.5. The relative standard error for this ratio may be estimated to be less than $1.414\sqrt{(.142)^2 + (.152)^2} = .29$. Therefore the true value of the ratio of the rates lies between $5.5e^{-.29 \times 2}$ and $5.5e^{.29 \times 2}$ with high confidence (95 percent). The interval explicitly is 3.08 to 9.82. It may be reemphasized that since the standard error estimate is an upper-bound, the interval is probably considerably wider than needed for 95 percent confidence.

Another observation is based on Table 4.1 with reference to Table 3.2. The observation is that the sampling variances represented in Table 4.1 are greatly reduced from the sampling variances of the raw FARS counts. If the raw counts are assumed to be Poisson distributed (see Appendix C for a discussion of this assumption) then the relative standard error of each cell count should be equal to the reciprocal of the square root of the mean value. The mean value is best estimated by the smoothed cell estimate. The relative standard error to compare this with is the relative standard error of the smoothed estimate in Table 4.1. For example, if the top left entry in Table 3.2 is considered, an estimate of $1./\sqrt{66.5} = .12$ is obtained for the relative standard error for the count in this cell. This may be compared to the relative standard error for the smoothed estimate obtained from Table 4.1 namely .0463. Other similar comparisons may be made:

(a) Top right hand cell. Relative standard error of raw count is estimated as $1/\sqrt{243.8} \doteq .064$ (from Table 3.2). Relative standard error of smoothed estimate from Table 4.1 is .0331.

(b) Bottom left corner cell. Compare $1/\sqrt{1.214} = .91$ from Table 3.2 to .156 from Table 4.1.

(c) Bottom right. $1/\sqrt{5.404} = .43$ vs. .135.

In general the standard error seems to have been reduced by a factor of at least 2 in most cases. This demonstrates the effectiveness of the log-linear smoothing process.

TABLE 4.1 RELATIVE STANDARD ERRORS OF THE SMOOTHED FATAL INVOLVEMENT ESTIMATES
(ESTIMATED STANDARD ERROR ÷ CELL ESTIMATE)

SEASON: SUMMER

		LAND USE:		URBAN				RURAL			
		VEHICLE AGE:		5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
		VEHICLE WEIGHT:		LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	.046320	.044076	.039381	.033345	.043797	.044029	.047152	.033142
			26-55	.043815	.034044	.049681	.031519	.039356	.032464	.040565	.027167
			GE 56	.057704	.057619	.049914	.046894	.058154	.046607	.067592	.049464
		FEMALE	LE 25	.079231	.061704	.047428	.049411	.058805	.049417	.054673	.051428
			26-55	.055731	.048462	.066143	.047032	.043019	.044005	.050674	.052843
			GE 56	.079139	.072868	.086323	.077799	.058831	.059739	.058016	.051837
	RUSH	MALE	LE 25	.058707	.054710	.051508	.047540	.042865	.033371	.041118	.040400
			26-55	.070617	.043791	.058921	.054090	.070841	.045904	.045856	.046470
			GE 56	.099824	.079282	.064597	.055605	.077874	.055267	.079659	.062434
		FEMALE	LE 25	.087828	.081502	.067517	.058931	.079890	.064531	.063348	.053240
			26-55	.065837	.051375	.073492	.050315	.063601	.054634	.062649	.069644
			GE 56	.083355	.067662	.082192	.081549	.077213	.070004	.076024	.081080
	LATE	MALE	LE 25	.041839	.037161	.030907	.033331	.037412	.037929	.030002	.023702
			26-55	.046237	.023019	.044952	.035300	.044528	.032014	.031750	.023512
			GE 56	.087095	.077457	.078081	.068098	.094199	.075876	.088669	.077652
		FEMALE	LE 25	.066337	.063135	.060710	.061332	.060441	.065944	.072364	.064257
			26-55	.048787	.049708	.044366	.043942	.052970	.050801	.060428	.063521
			GE 56	.150728	.128394	.130817	.108615	.139239	.117561	.118738	.111759
MORE THAN 1	OTHER	MALE	LE 25	.049509	.046098	.032985	.038750	.037353	.031681	.038117	.025301
			26-55	.049126	.036840	.044648	.039006	.037501	.029350	.037956	.026152
			GE 56	.074128	.062206	.061302	.056368	.065464	.040404	.065572	.046344
		FEMALE	LE 25	.067748	.051830	.055938	.056544	.044492	.050310	.049565	.054425
			26-55	.057352	.048798	.067557	.049896	.040393	.042173	.046421	.037502
			GE 56	.102655	.083538	.096207	.082125	.085403	.070886	.082865	.075363
	RUSH	MALE	LE 25	.064690	.048466	.065947	.050340	.049853	.042910	.045670	.036490
			26-55	.066845	.052557	.058995	.051814	.060779	.050150	.052962	.047232
			GE 56	.112641	.095899	.089147	.086411	.095184	.072643	.097131	.080745
		FEMALE	LE 25	.089874	.081851	.087593	.086047	.075695	.064667	.066646	.064927
			26-55	.067511	.075218	.051502	.053927	.063373	.074711	.058753	.081296
			GE 56	.127356	.107406	.091718	.072455	.096364	.086337	.089386	.082767
	LATE	MALE	LE 25	.051201	.041232	.035747	.038909	.037841	.029574	.027054	.022095
			26-55	.050060	.037982	.038830	.038524	.046006	.033036	.030891	.035260
			GE 56	.104995	.095568	.078732	.087875	.106817	.084903	.081096	.082914
		FEMALE	LE 25	.072162	.054355	.050527	.058745	.049353	.047908	.045779	.047517
			26-55	.060439	.064176	.060050	.050008	.057024	.062150	.056570	.055551
			GE 56	.156290	.150794	.117544	.122429	.124219	.120459	.122709	.134757

TABLE 4.1 (CONTINUED). RELATIVE STANDARD ERRORS OF THE SMOOTHED FATAL INVOLVEMENT ESTIMATES
(ESTIMATED STANDARD ERROR ÷ CELL ESTIMATE)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	.049479	.041331	.044997	.030945	.040302	.030939	.048453	.036816
			26-55	.042424	.029376	.052242	.033307	.036439	.030315	.035359	.027802
			GE 56	.072391	.055625	.049691	.032823	.061518	.051411	.060975	.041457
		FEMALE	LE 25	.069651	.050680	.043385	.046855	.053579	.042201	.046541	.046935
			26-55	.047648	.046334	.050393	.036850	.053690	.055313	.051120	.055335
			GE 56	.075562	.077107	.077773	.070901	.054725	.056058	.071557	.055558
	RUSH	MALE	LE 25	.049973	.056106	.057083	.061664	.045152	.045266	.053306	.058899
			26-55	.071240	.058133	.059734	.062829	.064434	.052767	.038490	.047892
			GE 56	.081149	.058174	.065573	.039527	.071418	.055331	.071167	.055773
		FEMALE	LE 25	.082681	.079874	.069033	.066057	.078079	.075065	.055147	.060683
			26-55	.071408	.061064	.088974	.066851	.067544	.062375	.066532	.065961
			GE 56	.093002	.083187	.086762	.085461	.084002	.081348	.072989	.087935
	LATE	MALE	LE 25	.042883	.036454	.033489	.027075	.041983	.036419	.042366	.032483
			26-55	.048137	.025534	.045142	.036296	.047050	.034868	.043358	.032260
			GE 56	.097011	.082670	.082428	.073997	.101531	.087716	.092754	.084554
		FEMALE	LE 25	.074723	.054922	.069314	.057106	.064323	.050999	.078006	.060724
			26-55	.053355	.050906	.054319	.054864	.056021	.054666	.063343	.066537
			GE 56	.152776	.131180	.139283	.116429	.136790	.115205	.127941	.109040
MORE THAN 1	OTHER	MALE	LE 25	.048538	.040217	.047053	.040842	.045524	.037224	.040455	.029041
			26-55	.048019	.036507	.044737	.038034	.039535	.037400	.031923	.027536
			GE 56	.083958	.049521	.060457	.042125	.072572	.043135	.058744	.036732
		FEMALE	LE 25	.062731	.052878	.056106	.055285	.045553	.055250	.040834	.052296
			26-55	.049134	.044362	.069464	.055637	.050404	.051188	.060384	.055321
			GE 56	.109748	.097088	.099327	.090438	.083995	.068761	.078569	.064897
	RUSH	MALE	LE 25	.060418	.058025	.062048	.054330	.044542	.048964	.042439	.043341
			26-55	.048884	.051944	.041631	.047406	.050372	.062443	.040456	.047659
			GE 56	.109463	.087157	.091568	.081047	.089675	.069457	.079319	.063438
		FEMALE	LE 25	.069339	.063288	.068299	.065351	.056397	.056479	.043039	.054153
			26-55	.068830	.073064	.067584	.061728	.052824	.066246	.070577	.085479
			GE 56	.140590	.121697	.106502	.091731	.107871	.099037	.077586	.077803
	LATE	MALE	LE 25	.044719	.038601	.036717	.032532	.045069	.037421	.039141	.029666
			26-55	.042500	.036389	.037525	.044171	.047081	.042869	.039805	.045096
			GE 56	.106770	.089074	.074692	.085912	.114777	.094039	.082967	.087374
		FEMALE	LE 25	.081127	.056419	.056380	.052047	.060725	.044947	.053736	.044290
			26-55	.063136	.066467	.064276	.054917	.063952	.068852	.060082	.061962
			GE 56	.154561	.148725	.108640	.114470	.121504	.120651	.118346	.124824

TABLE 4.2 RELATIVE STANDARD ERRORS OF THE SMOOTHED VMT ESTIMATES (ESTIMATED STANDARD ERRORS÷CELL ESTIMATE)

SEASON: SUMMER

LAND USE:				URBAN				RURAL			
VEHICLE AGE:				5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
VEHICLE WEIGHT:				LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.134675	0.096776	0.080223	0.090540	0.176856	0.161869	0.144191	0.148918
			26-55	0.093786	0.046700	0.059536	0.071200	0.117383	0.077112	0.127883	0.078895
			GE 56	0.175371	0.099516	0.125624	0.117708	0.278893	0.137574	0.262382	0.201970
		FEMALE	LE 25	0.132187	0.124782	0.111876	0.115602	0.146997	0.142547	0.169123	0.134222
			26-55	0.092205	0.071560	0.076193	0.068672	0.138820	0.109526	0.122352	0.129725
			GE 56	0.172887	0.121067	0.122249	0.108765	0.236308	0.143283	0.298186	0.153528
	RUSH	MALE	LE 25	0.117793	0.096899	0.085529	0.092407	0.186148	0.138751	0.114775	0.119461
			26-55	0.098589	0.057472	0.051636	0.076968	0.147946	0.104802	0.166329	0.097903
			GE 56	0.156497	0.087339	0.176953	0.122760	0.213707	0.118778	0.226290	0.184972
		FEMALE	LE 25	0.134570	0.133769	0.123705	0.137934	0.165333	0.111053	0.190628	0.126180
			26-55	0.085574	0.069413	0.082528	0.074181	0.144012	0.116426	0.132220	0.116135
			GE 56	0.132509	0.111447	0.134867	0.131804	0.236415	0.154634	0.304798	0.150144
	LATE	MALE	LE 25	0.162021	0.113508	0.115710	0.130426	0.150654	0.164704	0.176527	0.151603
			26-55	0.129570	0.071898	0.111242	0.066784	0.132132	0.127856	0.171829	0.120465
			GE 56	0.205637	0.139190	0.238254	0.156816	0.321313	0.214093	0.321499	0.287528
		FEMALE	LE 25	0.138326	0.124747	0.131220	0.168210	0.164761	0.157728	0.217405	0.134539
			26-55	0.125706	0.102627	0.104796	0.097047	0.173468	0.144508	0.131561	0.156198
			GE 56	0.208965	0.192901	0.251811	0.150096	0.283207	0.221943	0.371221	0.228672
MORE THAN ONE	OTHER	MALE	LE 25	0.117792	0.077416	0.108592	0.084043	0.159521	0.192703	0.119414	0.166552
			26-55	0.080267	0.043256	0.107937	0.077715	0.181456	0.092208	0.134727	0.136196
			GE 56	0.164873	0.133683	0.171095	0.137058	0.207184	0.139742	0.219275	0.158276
		FEMALE	LE 25	0.149149	0.150054	0.103752	0.106995	0.176394	0.217113	0.161810	0.128054
			26-55	0.094357	0.058021	0.117978	0.099364	0.150261	0.076483	0.109996	0.119684
			GE 56	0.188608	0.147306	0.191436	0.178005	0.387987	0.258333	0.315807	0.158994
	RUSH	MALE	LE 25	0.098745	0.128743	0.111478	0.111837	0.158333	0.160128	0.118689	0.149983
			26-55	0.097496	0.067282	0.126413	0.104793	0.191895	0.090927	0.187344	0.158067
			GE 56	0.191357	0.143333	0.187337	0.138616	0.160342	0.142891	0.242391	0.171244
		FEMALE	LE 25	0.148906	0.171106	0.115152	0.143063	0.152507	0.211468	0.145761	0.178404
			26-55	0.085544	0.065005	0.100300	0.098008	0.161655	0.109451	0.120902	0.161303
			GE 56	0.194746	0.117406	0.245503	0.179896	0.374804	0.253151	0.346333	0.149727
	LATE	MALE	LE 25	0.109264	0.101754	0.110465	0.086219	0.151437	0.195763	0.095230	0.143254
			26-55	0.103922	0.085524	0.145959	0.091446	0.165282	0.103919	0.167533	0.168288
			GE 56	0.272351	0.156480	0.254150	0.170915	0.295231	0.179417	0.221033	0.211155
		FEMALE	LE 25	0.195046	0.218941	0.163974	0.145465	0.219413	0.242452	0.218251	0.150546
			26-55	0.129512	0.108905	0.155702	0.132928	0.216686	0.183406	0.180811	0.230599
			GE 56	0.271059	0.228644	0.328575	0.185364	0.510567	0.333560	0.442290	0.210822

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TABLE 4.2 (CONTINUED). RELATIVE STANDARD ERRORS OF THE SMOOTHED VMT ESIMATED (ESIMATED STANDARD ERROR÷CELL ESIMATE)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.082390	0.099597	0.101086	0.119920	0.147831	0.139581	0.183346	0.142241
			26-55	0.091977	0.061227	0.090119	0.068458	0.122594	0.068903	0.130321	0.073378
			GE 56	0.239025	0.100306	0.141078	0.105755	0.275769	0.135611	0.234536	0.164081
		FEMALE	LE 25	0.100120	0.154309	0.096662	0.064793	0.190291	0.128661	0.214926	0.073709
			26-55	0.087170	0.076190	0.100606	0.057404	0.098490	0.106656	0.145163	0.116264
			GE 56	0.168771	0.123747	0.151086	0.161172	0.206401	0.172850	0.298623	0.184150
	RUSH	MALE	LE 25	0.104887	0.105912	0.133249	0.109368	0.140194	0.123403	0.143327	0.105804
			26-55	0.098225	0.068429	0.084877	0.057911	0.135699	0.092824	0.147840	0.072042
			GE 56	0.220540	0.119363	0.170717	0.122039	0.235888	0.165877	0.213479	0.163236
		FEMALE	LE 25	0.116629	0.152934	0.115470	0.068841	0.193563	0.113802	0.222441	0.079593
			26-55	0.072943	0.070683	0.097825	0.049682	0.100703	0.118075	0.152054	0.103993
			GE 56	0.122735	0.125172	0.147199	0.175359	0.199895	0.186006	0.293847	0.187200
	LATE	MALE	LE 25	0.148684	0.089584	0.142971	0.131713	0.137986	0.133054	0.212290	0.157528
			26-55	0.112022	0.092415	0.116665	0.093298	0.100190	0.097822	0.156155	0.118313
			GE 56	0.288593	0.151760	0.250828	0.145616	0.262382	0.222345	0.265907	0.272277
		FEMALE	LE 25	0.137629	0.145754	0.122209	0.093403	0.232532	0.144013	0.264106	0.078136
			26-55	0.099317	0.093296	0.091577	0.067140	0.139213	0.130901	0.154372	0.140975
			GE 56	0.251111	0.164784	0.281337	0.143188	0.261610	0.214952	0.388618	0.239969
MORE THAN ONE	OTHER	MALE	LE 25	0.134957	0.119626	0.109101	0.095429	0.170581	0.184566	0.129908	0.153974
			26-55	0.118093	0.062289	0.110580	0.096871	0.241137	0.139359	0.151752	0.127594
			GE 56	0.206840	0.111093	0.159239	0.123693	0.196984	0.117245	0.250884	0.165192
		FEMALE	LE 25	0.170375	0.197444	0.125985	0.124387	0.222533	0.174821	0.213830	0.124940
			26-55	0.121118	0.088774	0.124606	0.090430	0.150295	0.132118	0.158719	0.102589
			GE 56	0.184124	0.162038	0.181717	0.201640	0.319773	0.262372	0.294224	0.208996
	RUSH	MALE	LE 25	0.144388	0.149479	0.143719	0.099202	0.168847	0.168194	0.134705	0.151858
			26-55	0.122147	0.045465	0.119560	0.092167	0.230994	0.114158	0.178214	0.134774
			GE 56	0.227442	0.142322	0.171565	0.141527	0.149828	0.140597	0.258513	0.191200
		FEMALE	LE 25	0.179859	0.196680	0.147205	0.126514	0.189405	0.152305	0.189868	0.169974
			26-55	0.115989	0.076478	0.119760	0.075962	0.140370	0.131070	0.159800	0.125106
			GE 56	0.183911	0.149601	0.255336	0.210274	0.285476	0.254791	0.325250	0.204442
	LATE	MALE	LE 25	0.195258	0.151441	0.145076	0.088522	0.208438	0.210546	0.134457	0.136886
			26-55	0.127377	0.101512	0.115775	0.094850	0.213807	0.137528	0.166194	0.153777
			GE 56	0.330158	0.134102	0.252086	0.145131	0.256928	0.159996	0.201615	0.220489
		FEMALE	LE 25	0.216777	0.218321	0.187401	0.120195	0.272489	0.177666	0.264150	0.122548
			26-55	0.139900	0.095804	0.161953	0.119028	0.186673	0.159210	0.214168	0.185757
			GE 56	0.294788	0.192843	0.341467	0.180829	0.450711	0.316852	0.445790	0.259331

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TABLE 4.3 RELATIVE STANDARD ERRORS OF THE FATAL INVOLVEMENT RATES (ESIMATED STANDARD ERRORS÷CELL ESIMATE)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.142418	0.106340	0.089368	0.096485	0.182198	0.167750	0.151705	0.152561
			26-55	0.103516	0.057792	0.077542	0.077065	0.123804	0.083675	0.134169	0.083442
			GE 56	0.184621	0.114993	0.135176	0.126705	0.284891	0.145254	0.270949	0.207938
		FEMALE	LE 25	0.154113	0.139204	0.121514	0.125719	0.158322	0.150870	0.177741	0.143737
			26-55	0.107739	0.086425	0.100898	0.083233	0.145332	0.118036	0.132430	0.140075
			GE 56	0.190139	0.141305	0.149655	0.133726	0.243521	0.155237	0.303777	0.162043
	RUSH	MALE	LE 25	0.131612	0.111277	0.099841	0.103918	0.191020	0.142708	0.121918	0.126107
			26-55	0.121271	0.072254	0.078345	0.094073	0.164032	0.114414	0.172535	0.108372
			GE 56	0.185624	0.117957	0.188375	0.134767	0.227453	0.131006	0.239901	0.195225
		FEMALE	LE 25	0.160695	0.156642	0.140931	0.149995	0.183623	0.128441	0.200878	0.136952
			26-55	0.107970	0.086357	0.110508	0.089635	0.157431	0.128608	0.146311	0.135416
			GE 56	0.156546	0.130379	0.157939	0.154992	0.248704	0.169742	0.314136	0.170638
	LATE	MALE	LE 25	0.167336	0.119437	0.119767	0.134618	0.155230	0.169015	0.179058	0.153445
			26-55	0.137573	0.075493	0.119981	0.075540	0.139433	0.131803	0.174738	0.122738
			GE 56	0.223321	0.159291	0.250722	0.170963	0.334836	0.227141	0.333502	0.297829
		FEMALE	LE 25	0.153410	0.139814	0.144584	0.179043	0.175497	0.170959	0.229132	0.149096
			26-55	0.134842	0.114031	0.113800	0.106531	0.181375	0.153178	0.144775	0.168620
			GE 56	0.257653	0.231723	0.283764	0.185273	0.315585	0.251156	0.389749	0.254538
MORE THAN ONE	OTHER	MALE	LE 25	0.127773	0.090102	0.113491	0.092546	0.163836	0.195290	0.125349	0.168463
			26-55	0.094107	0.056817	0.116807	0.086955	0.185291	0.096767	0.139971	0.138684
			GE 56	0.180771	0.147447	0.181746	0.148197	0.217280	0.144986	0.228869	0.165495
		FEMALE	LE 25	0.163815	0.158753	0.117446	0.121017	0.181919	0.222866	0.169231	0.139140
			26-55	0.110419	0.075813	0.135951	0.111188	0.155596	0.087340	0.119391	0.125422
			GE 56	0.214735	0.169345	0.214251	0.196037	0.397275	0.267882	0.326498	0.175951
	RUSH	MALE	LE 25	0.118049	0.137564	0.129524	0.122644	0.165996	0.165778	0.127173	0.154843
			26-55	0.118210	0.085376	0.139502	0.116903	0.201290	0.103840	0.194692	0.164973
			GE 56	0.222049	0.172456	0.207467	0.163344	0.186466	0.160296	0.261128	0.189326
		FEMALE	LE 25	0.173926	0.189675	0.144681	0.166946	0.170259	0.221140	0.160274	0.189851
			26-55	0.108975	0.099416	0.112750	0.111864	0.173633	0.132519	0.134422	0.180631
			GE 56	0.232692	0.159123	0.262076	0.193939	0.386993	0.267469	0.357682	0.171080
	LATE	MALE	LE 25	0.120665	0.109791	0.116105	0.094592	0.156093	0.197984	0.098998	0.144948
			26-55	0.115351	0.093579	0.151036	0.099229	0.171566	0.109043	0.170357	0.171942
			GE 56	0.291889	0.183355	0.266065	0.192182	0.313961	0.198492	0.235440	0.226851
		FEMALE	LE 25	0.207967	0.225587	0.171582	0.156879	0.224895	0.247140	0.223001	0.157867
			26-55	0.142921	0.126408	0.166881	0.142023	0.224063	0.193650	0.189453	0.238164
			GE 56	0.312889	0.273892	0.348967	0.222145	0.525461	0.354645	0.458997	0.250211

4.3 F

TABLE 4.3 (CONTINUED). RELATIVE STANDARD ERRORS OF THE FATAL INVOLVEMENT RATES
(ESTIMATED STANDARD ERROR÷CELL ESIMATE)

SEASON: WINTER

OCCUPANTS	TIME	SEX	AGE	URBAN, 5 YRS OR LESS, LIGHT	URBAN, 5 YRS OR LESS, HEAVY	URBAN, OVER 5 YRS, LIGHT	URBAN, OVER 5 YRS, HEAVY	RURAL, 5 YRS OR LESS, LIGHT	RURAL, 5 YRS OR LESS, HEAVY	RURAL, OVER 5 YRS, LIGHT	RURAL, OVER 5 YRS, HEAVY
ONE	OTHER	MALE	LE 25	0.096106	0.107032	0.110649	0.123048	0.154226	0.144387	0.189640	0.147442
			26-55	0.101290	0.067910	0.104166	0.076130	0.127895	0.075278	0.135033	0.070468
			GE 56	0.249746	0.114697	0.149573	0.110731	0.202548	0.145029	0.242332	0.169237
		FEMALE	LE 25	0.121964	0.162418	0.105952	0.079959	0.197690	0.135406	0.219907	0.087304
			26-55	0.099342	0.089172	0.112521	0.068214	0.112174	0.120145	0.153901	0.130530
			GE 56	0.184914	0.145804	0.169928	0.176077	0.214532	0.181713	0.307076	0.192348
	RUSH	MALE	LE 25	0.116184	0.119855	0.144961	0.125554	0.147286	0.131443	0.152919	0.121093
			26-55	0.121340	0.089789	0.103789	0.085447	0.150219	0.106774	0.152768	0.086508
			GE 56	0.234996	0.113785	0.182878	0.128281	0.246462	0.174862	0.225029	0.172502
		FEMALE	LE 25	0.142963	0.172536	0.134532	0.095407	0.208718	0.136340	0.229175	0.100087
			26-55	0.102078	0.093407	0.132235	0.083291	0.121257	0.133538	0.165973	0.125347
			GE 56	0.153991	0.150294	0.170866	0.195075	0.216828	0.203017	0.302776	0.206825
	LATE	MALE	LE 25	0.154744	0.096717	0.146841	0.134467	0.144252	0.137948	0.216476	0.160842
			26-55	0.121926	0.095870	0.125094	0.100109	0.110688	0.103857	0.162063	0.122632
			GE 56	0.304462	0.172816	0.264025	0.163339	0.281341	0.239022	0.281620	0.285103
		FEMALE	LE 25	0.156605	0.155758	0.140497	0.109477	0.241264	0.152776	0.225305	0.098958
			26-55	0.112742	0.106280	0.106475	0.086705	0.150062	0.141857	0.166862	0.155888
			GE 56	0.293934	0.210623	0.313927	0.184549	0.295214	0.243878	0.409136	0.263588
MORE THAN ONE	OTHER	MALE	LE 25	0.143420	0.126206	0.118815	0.103802	0.176551	0.188283	0.136062	0.156689
			26-55	0.127483	0.072199	0.119287	0.104070	0.244357	0.144290	0.155073	0.130532
			GE 56	0.222231	0.121630	0.170330	0.130670	0.209927	0.124928	0.257620	0.169227
		FEMALE	LE 25	0.181557	0.204402	0.137914	0.137292	0.227148	0.183355	0.217694	0.135443
			26-55	0.130705	0.099241	0.142660	0.106175	0.158522	0.141687	0.169817	0.116555
			GE 56	0.214351	0.188898	0.207091	0.220993	0.330621	0.271238	0.304534	0.218840
	RUSH	MALE	LE 25	0.156519	0.160346	0.156541	0.113105	0.174623	0.175176	0.141232	0.152921
			26-55	0.131565	0.069031	0.126601	0.103644	0.246423	0.130120	0.182748	0.142953
			GE 56	0.252412	0.166889	0.194472	0.163090	0.174614	0.156818	0.220408	0.201449
		FEMALE	LE 25	0.192262	0.206612	0.162278	0.142395	0.197623	0.162440	0.194685	0.178405
			26-55	0.134874	0.105769	0.137514	0.097880	0.149980	0.146860	0.174691	0.151519
			GE 56	0.231492	0.192812	0.276657	0.229411	0.305176	0.273362	0.334375	0.218746
	LATE	MALE	LE 25	0.200313	0.156283	0.149651	0.094311	0.213555	0.213846	0.140039	0.140064
			26-55	0.134200	0.107238	0.121704	0.104631	0.218229	0.144053	0.170894	0.160253
			GE 56	0.346993	0.169807	0.262919	0.160653	0.281399	0.185586	0.218019	0.237170
		FEMALE	LE 25	[illegible]	[illegible]	0.195698	0.130980	[illegible]	[illegible]	[illegible]	[illegible]
			26-55	0.153387	0.112603	0.174742	0.131086	0.197323	0.173460	0.222436	0.198819
			GE 56	[illegible]	[illegible]	[illegible]	0.214619	0.466801	0.332045	0.461232	[illegible]

5.0 SMALL CAR/LARGE CAR FATAL ACCIDENT INVOLVEMENT RATE EXPOSURE STUDY

This section provides an example of the data and methods developed in this report. This section compares the fatal involvement rates of light cars with heavy cars. The measure to be used for this comparison is the ratio of the fatal involvement rates for light cars (3,000 lbs. or less) to that for heavy cars (over 3,000 lbs.). The multivariate fatal involvement rates shown in Table 3.5 permit this comparison to be made while controlling for the seven variables other than vehicle weight in Table 1.1. Further, they permit the dependence of this ratio on these other variables to be determined.

The ratios of fatal involvement rates are given in Table 5.1. The table gives the ratio of the fatal involvement rate for light vehicles to that for heavy vehicles for each combination of levels of the other seven variables. There are 288 cells in this table, which has the same format as Table 3.5. Beside each fatal involvement rate ratio is a sequence of seven small numbers indicating the level of each of the seven variables (these are of help in some detailed studies of the table, but are not of any interest in this report). Table 5.2 gives the relative standard errors of the fatal involvement rate ratios given in Table 5. These are calculated using the sample splitting techniques described in Section 4.*

An examination of Table 5.1 shows that the largest fatal involvement rate ratio is just under 3.0 while the smallest is just over .56. Based on the relative standard errors in Table 5.2, most comparisons in Table 5.1 unlike those in Table 3.5 are not significant. The fatal involvement rate ratio changes considerably from cell to cell but not by a large enough amount to make an analysis easy.

*The relative variance of the ratio of corresponding light and heavy cells is calculated separately for the numerator (FARS) and the denominator (NPTS). The relative variance of the fatal involvement rate ratio itself is equal to the sum of these relative variances. The relative standard error is the square root of the relative variance. As noted in Section 4, it can be interpreted as the ratio of the standard error of the estimate to the estimate itself (in this case fatal involvement rate ratio). The details of calculating relative variances using FARS and NPTS are given in Section 4.

Table 5.1

Primary Measure of the Effect of Car Size: Ratio of Fatal Involvement Rates (FIR) Light/Heavy

SEASON: SUMMER

# OCCUPANTS	TIME	SEX	AGE	URBAN, 5 YRS OR LESS: RATE	URBAN, 5 YRS OR LESS: VARIABLES	URBAN, OVER 5 YRS: RATE	URBAN, OVER 5 YRS: VARIABLES	RURAL, 5 YRS OR LESS: RATE	RURAL, 5 YRS OR LESS: VARIABLES	RURAL, OVER 5 YRS: RATE	RURAL, OVER 5 YRS: VARIABLES
ONE	OTHER	MALE	LE 25	.694030	1111111	.668965	1111211	.685420	1111121	.772302	1111221
			26-55	.976341	2111111	.903631	2111211	1.123656	2111121	1.215591	2111221
			GE 56	.970168	3111111	1.121986	3111211	1.529439	3111121	2.067053	3111221
		FEMALE	LE 25	.693360	1211111	.560333	1211211	.710313	1211121	.670846	1211221
			26-55	1.054655	2211111	.818308	2211211	1.487617	2211121	1.348661	2211221
			GE 56	1.035873	3211111	1.003628	3211211	.944476	3211121	1.669885	3211221
	RUSH	MALE	LE 25	.946154	1121111	.912014	1121211	.934364	1121121	1.052740	1121221
			26-55	.864271	2121111	.798785	2121211	.993881	2121121	1.074899	2121221
			GE 56	.894420	3121111	1.034559	3121211	1.416476	3121121	1.906136	3121221
		FEMALE	LE 25	.935246	1221111	.755797	1221211	.958368	1221121	.905010	1221221
			26-55	.923524	2221111	.715562	2221211	1.301812	2221121	1.180578	2221221
			GE 56	.945223	3221111	.915684	3221211	.862052	3221121	.976253	3221221
	LATE	MALE	LE 25	.877655	1131111	.845971	1131211	.866705	1131121	.976559	1131221
			26-55	.961294	2131111	.889624	2131211	1.106322	2131121	1.196654	2131221
			GE 56	.863184	3131111	.998185	3131211	1.361615	3131121	1.840427	3131221
		FEMALE	LE 25	1.043225	1231111	.842763	1231211	1.068500	1231121	1.009290	1231221
			26-55	1.234995	2231111	.957835	2231211	1.742440	2231121	1.578791	2231221
			GE 56	1.096271	3231111	1.061639	3231211	.998960	3231121	1.133843	3231221
MORE THAN 1	OTHER	MALE	LE 25	.718496	1112111	.970025	1112211	.709517	1112121	1.119709	1112221
			26-55	1.011424	2112111	1.310617	2112211	1.163429	2112121	1.762408	2112221
			GE 56	1.004557	3112111	1.626413	3112211	1.583132	3112121	2.997026	3112221
		FEMALE	LE 25	.717891	1212111	.812447	1212211	.735388	1212121	.972688	1212221
			26-55	1.091459	2212111	1.185984	2212211	1.540000	2212121	1.955422	2212221
			GE 56	1.072228	3212111	1.454964	3212211	.977905	3212121	1.551202	3212221
	RUSH	MALE	LE 25	.979579	1122111	1.322164	1122211	.967339	1122121	1.526413	1122221
			26-55	.894410	2122111	1.158389	2122211	1.028773	2122121	1.558577	2122221
			GE 56	.926396	3122111	1.500124	3122211	1.459907	3122121	2.764329	3122221
		FEMALE	LE 25	.968641	1222111	1.096126	1222211	.992149	1222121	1.312077	1222221
			26-55	.955556	2222111	1.037649	2222211	1.347444	2222121	1.711343	2222221
			GE 56	.978524	3222111	1.328010	3222211	.892185	3222121	1.416152	3222221
	LATE	MALE	LE 25	.908614	1132111	1.226550	1132211	.897273	1132121	1.415841	1132221
			26-55	.995327	2132111	1.289758	2132211	1.145124	2132121	1.735028	2132221
			GE 56	.893709	3132111	1.447375	3132211	1.408771	3132121	2.666458	3132221
		FEMALE	LE 25	1.080157	1232111	1.222237	1232211	1.106456	1232121	1.463020	1232221
			26-55	1.278440	2232111	1.388776	2232211	1.803132	2232121	2.289958	2232221
			GE 56	1.135115	3232111	1.541184	3232211	1.035569	3232121	1.639588	3232221

5.1

Table 5.1 (cont'd)
Primary Measure of the Effect of Car Size: Ratio of Fatal Involvement Rates (FIR) Light/Heavy (continued)

SEASON: WINTER			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	.606305	1111112	.584439	1111212	.598717	1111122	.674617	1111222
			26-55	.852910	2111112	.789360	2111212	.981690	2111122	1.061808	2111222
			GE 56	.847458	3111112	.979952	3111212	1.335993	3111122	1.805702	3111222
		FEMALE	LE 25	.824592	1211112	.666227	1211212	.844481	1211122	.797535	1211222
			26-55	1.254069	2211112	.972343	2211212	1.768624	2211122	1.603783	2211222
			GE 56	1.231231	3211112	1.193292	3211212	1.123096	3211122	1.272128	3211222
	RUSH	MALE	LE 25	.826490	1121112	.796677	1121212	.816248	1121122	.919614	1121222
			26-55	.754200	2121112	.697761	2121212	.868157	2121122	.939017	2121222
			GE 56	.781565	3121112	.903755	3121212	1.231818	3121122	1.665073	3121222
		FEMALE	LE 25	1.112476	1221112	.898781	1221212	1.139482	1221122	1.075972	1221222
			26-55	1.097470	2221112	.850900	2221212	1.547741	2221122	1.403327	2221222
			GE 56	1.123760	3221112	1.088991	3221212	1.024493	3221122	1.161132	3221222
	LATE	MALE	LE 25	.766663	1131112	.739035	1131212	.757157	1131122	.853160	1131222
			26-55	.839766	2131112	.777147	2131212	.966367	2131122	1.045276	2131222
			GE 56	.754004	3131112	.871944	3131212	1.189074	3131122	1.604676	3131222
		FEMALE	LE 25	1.240217	1231112	1.002057	1231212	1.270112	1231122	1.199766	1231222
			26-55	1.468289	2231112	1.138777	2231212	2.070963	2231122	1.877515	2231222
			GE 56	1.302801	3231112	1.262426	3231212	1.190580	3231122	1.349300	3231222
MORE THAN 1	OTHER	MALE	LE 25	.627566	1112112	.847373	1112212	.619876	1112122	.978133	1112222
			26-55	.883045	2112112	1.144798	2112212	1.016539	2112122	1.539705	2112222
			GE 56	.877240	3112112	1.420966	3112212	1.383404	3112122	2.618176	3112222
		FEMALE	LE 25	.853495	1212112	.965940	1212212	.874275	1212122	1.156330	1212222
			26-55	1.297362	2212112	1.410061	2212212	1.831119	2212122	2.325104	2212222
			GE 56	1.274586	3212112	1.729886	3212212	1.162570	3212122	1.843956	3212222
	RUSH	MALE	LE 25	.855602	1122112	1.155193	1122212	.845069	1122122	1.333303	1122222
			26-55	.781070	2122112	1.011888	2122212	.898538	2122122	1.361378	2122222
			GE 56	.809227	3122112	1.310464	3122212	1.275309	3122122	2.414610	3122222
		FEMALE	LE 25	1.151663	1222112	1.303191	1222212	1.179622	1222122	1.560047	1222222
			26-55	1.136071	2222112	1.234391	2222212	1.602906	2222122	2.034915	2222222
			GE 56	1.163539	3222112	1.578035	3222212	1.060799	3222122	1.683703	3222222
	LATE	MALE	LE 25	.793730	1132112	1.071547	1132212	.783937	1132122	1.237198	1132222
			26-55	.869468	2132112	1.126692	2132212	1.000312	2132122	1.515512	2132222
			GE 56	.780554	3132112	1.263812	3132212	1.230647	3132122	2.329792	3132222
		FEMALE	LE 25	1.283996	1232112	1.453064	1232212	1.315037	1232122	1.739115	1232222
			26-55	1.520025	2232112	1.650895	2232212	2.144829	2232122	2.722795	2232222
			GE 56	1.349092	3232112	1.830993	3232212	1.231490	3232122	1.957190	3232222

TABLE 5.2

Relative Standard Errors of the Measure: FIR Light/ Heavy
(Sample Splitting Technique)

SEASON: SUMMER

LAND USE:				URBAN				RURAL			
VEHICLE AGE:				5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
VEHICLE WEIGHT:				RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.152121		0.128458		0.214918		0.190666	
			26-55	0.097175		0.103767		0.133963		0.097725	
			GE 56	0.226545		0.166847		0.240155		0.217526	
		FEMALE	LE 25	0.202993		0.149581		0.209625		0.210755	
			26-55	0.131746		0.126138		0.140804		0.129877	
			GE 56	0.193498		0.196528		0.284251		0.280941	
	RUSH	MALE	LE 25	0.135098		0.129570		0.160597		0.145264	
			26-55	0.115440		0.105673		0.151760		0.111740	
			GE 56	0.215381		0.183771		0.204461		0.211796	
		FEMALE	LE 25	0.198627		0.185007		0.206986		0.231052	
			26-55	0.130432		0.120462		0.143286		0.141255	
			GE 56	0.184518		0.231509		0.293683		0.317993	
	LATE	MALE	LE 25	0.143868		0.158926		0.186130		0.180920	
			26-55	0.120765		0.123080		0.126383		0.121018	
			GE 56	0.305181		0.269861		0.278612		0.214985	
		FEMALE	LE 25	0.180383		0.188090		0.228085		0.263194	
			26-55	0.162282		0.126181		0.169185		0.169651	
			GE 56	0.303020		0.320054		0.363073		0.350797	
MORE THAN ONE	OTHER	MALE	LE 25	0.137390		0.114594		0.197932		0.168102	
			26-55	0.096323		0.095589		0.139671		0.109888	
			GE 56	0.225592		0.156746		0.230960		0.196063	
		FEMALE	LE 25	0.179460		0.157245		0.197749		0.210428	
			26-55	0.124681		0.134742		0.136415		0.126177	
			GE 56	0.228503		0.214830		0.313068		0.297566	
	RUSH	MALE	LE 25	0.133754		0.140845		0.160965		0.137315	
			26-55	0.128092		0.101382		0.166207		0.130671	
			GE 56	0.221669		0.202228		0.206364		0.215773	
		FEMALE	LE 25	0.194882		0.215556		0.207509		0.244229	
			26-55	0.147778		0.122248		0.160844		0.152045	
			GE 56	0.243648		0.251741		0.322973		0.333495	
	LATE	MALE	LE 25	0.138807		0.153916		0.175185		0.163180	
			26-55	0.103297		0.108779		0.117188		0.129269	
			GE 56	0.306565		0.285620		0.272647		0.219908	
		FEMALE	LE 25	0.168089		0.189088		0.217797		0.255618	
			26-55	0.151295		0.136198		0.158661		0.165335	
			GE 56	0.325624		0.344155		0.371347		0.379318	

TABLE 5.2 (cont'd)
Relative Standard Errors of the Measure: FIR Light/FIR Heavy
(Sample Splitting Technique) (continued)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.119678		0.125508		0.183759		0.190777	
			26-55	0.088406		0.101898		0.135049		0.116335	
			GE 56	0.245020		0.165126		0.244251		0.208905	
		FEMALE	LE 25	0.171143		0.128484		0.191195		0.219395	
			26-55	0.111671		0.123404		0.127856		0.158070	
			GE 56	0.209877		0.202728		0.305974		0.316697	
	RUSH	MALE	LE 25	0.115250		0.150264		0.141724		0.168258	
			26-55	0.118433		0.109018		0.154441		0.129251	
			GE 56	0.212252		0.175662		0.199683		0.196486	
		FEMALE	LE 25	0.175644		0.178499		0.199203		0.245015	
			26-55	0.129925		0.151109		0.134845		0.172362	
			GE 56	0.191216		0.227760		0.307772		0.336139	
	LATE	MALE	LE 25	0.117251		0.160863		0.158872		0.188493	
			26-55	0.115352		0.118775		0.129139		0.141360	
			GE 56	0.322983		0.276458		0.289140		0.217891	
		FEMALE	LE 25	0.155098		0.176912		0.212546		0.274252	
			26-55	0.147245		0.136373		0.149457		0.188378	
			GE 56	0.316691		0.334644		0.380675		0.380180	
MORE THAN ONE	OTHER	MALE	LE 25	0.115433		0.119978		0.180610		0.170864	
			26-55	0.108962		0.096686		0.157445		0.130817	
			GE 56	0.248986		0.157085		0.244132		0.188535	
		FEMALE	LE 25	0.157935		0.147270		0.190056		0.223660	
			26-55	0.113761		0.151026		0.131375		0.167898	
			GE 56	0.255394		0.234265		0.337234		0.327687	
	RUSH	MALE	LE 25	0.134675		0.156328		0.151856		0.155655	
			26-55	0.131729		0.093450		0.181109		0.147280	
			GE 56	0.236033		0.199906		0.209950		0.194361	
		FEMALE	LE 25	0.164583		0.196568		0.194168		0.253634	
			26-55	0.149152		0.153007		0.149046		0.190607	
			GE 56	0.259213		0.260962		0.342362		0.348417	
	LATE	MALE	LE 25	0.124044		0.158667		0.161549		0.173978	
			26-55	0.110501		0.110045		0.137107		0.152144	
			GE 56	0.324991		0.289352		0.290308		0.223299	
		FEMALE	LE 25	0.153929		0.180884		0.212984		0.270465	
			26-55	0.144273		0.148270		0.149655		0.189128	
			GE 56	0.338430		0.349040		0.392591		0.402305	

In spite of the considerable variability of the fatal involvement rate ratio from cell to cell in Table 5.1 and the considerable noisiness in the individual cells, it is desirable to have a summary of the information it contains. In particular, the answers to simple questions are sought:

1. Overall, can we say that light or heavy cars tend to have higher fatal involvement rates in similar situations?

2. On which variables does the ratio of fatal involvement rates (light/heavy) depend most strongly? Do these variables have a consistent effect?

Any attempt at a simple analysis quickly reveals that the presence of higher order interactions makes it hard to determine simple effects.

The chief tool to be used in this analysis is the weighted average over cells of the logarithm of the ratio of fatal involvement rate (FIR) of light cars to that of heavy cars. The weighting factor is estimated fatalities in each cell (as given in Table 3.2).

This may be illustrated by calculating the overall comparison of light to heavy vehicles averaged over all cells.

Consider

$$\frac{\sum_{\text{cells}} \log \left(\text{FIR (light)}/\text{FIR (heavy)}\right) * \text{Fatal Involvements}}{\sum_{\text{cells}} \text{Fatal Involvements}} = \log R$$

Here FIR (light) denotes the fatal involvement rate for light vehicles for a particular combination of the seven variables (i.e., a particular cell). FIR (light)/FIR (heavy) denotes the ratio of fatal involvement rates light to heavy. The factor Fatal Involvements is a weighting factor (it is specific to the cell, it is the estimated fatal involvements in Table 3.2). The sum over cells is over all cells in this case. Since the average of the logarithm of the FIR ratio is being calculated, the anti-logarithm is taken at the end to get R, fatal involvement -

weighted average ratio. When this formula is applied to Table 5.1, the result is R = 1.059. On the average, overall, light cars have a 5.9 percent higher fatal involvement rate than heavy cars. This average is obtained while controlling for the other seven factors:

a. Driver Age
b. Driver Sex
c. Vehicle Age
d. Time of Day
e. Season
f. Urban/Rural
g. Number of Occupants

These factors are controlled for in the sense that FIR ratios are obtained for specific values of these variables and then averaged. The effect of any tendency for either light or heavy cars to be used more in particular circumstances identifiable by these variables (e.g., by young drivers late at night) is eliminated (to the extent that the categories for each variable are fine enough).

To find the fatal involvement rate ratio without controlling for these variables, the overall fatal involvement rate for small cars (total fatalities divided by total VMT) is divided by the rate for large cars. This leads to the estimate that small cars have a fatal involvement rate which is 8.9 percent* higher than for large cars. Since this is more unfavorable to small cars than the ratio controlling for the other factors (i.e., 8.9 percent to 5.9 percent), it may be concluded that the circumstances for small cars (their drivers, environment, etc.) lead to their getting into more fatal accidents than just the specific characteristics of the cars themselves.

Before calculating how the fatal invovlement rate ratio is influenced by certain factors, it should be pointed out that the estimated overall average fatal involvement rate ratio 1.059, although it shows that small cars get into more fatal accidents than large cars, is really quite close to 1. This may seem a little

*This number is derived from the "Vehicle Weight" row of Table 2.5 as follows: (Fatal Involvements LE 3000 lbs)/(VMT LE 3000 lbs) ÷ (Fatal Involvements GT 3000 lbs)/(VMT GT 3000 lbs) = (12,504/212.6)/(24,805/459.1) = 1.089

paradoxical since small cars afford less occupant protection than large cars. However, a large component of the crashworthiness advantage that large cars have is nullified in the FIR ratio measures. Specifically all fatal accidents between small and large cars are counted against both the small car involved and the large car involved regardless of which vehicle(s) a fatality occurred in. Thus, large cars may be "safer" for their occupants but are only slightly better in terms of their fatal involvement rate.

The next three subsections deal with the selection of the most important factors to examine for a simpler representation of the dependences of the FIR ratio (fatal involvement rate ratio) than in Table 5.1. Basically the criteria are strength and consistency of effect. There are three techniques to be used to find out which factors have the strongest, most consistent effect:

1. Examining individual cells
2. Examining the log-linear model representing the FIR ratio
3. Examining weighted averages over groups of cells.

5.1 Examining Single Cells

The chief idea here is to look for cells that have FIR ratios significantly higher or significantly lower than the mean. To see if the FIR ratio is significantly large or small, the weighted mean of the log of the FIR ratio is subtracted from the log of the FIR ratio for each cell. The result is divided by the standard error of the log of the FIR ratio (for the particular cell).* If the result is larger than 2.326, or smaller than -2.326, the FIR ratio for that cell is labelled as "significant". The number 2.326 was chosen somewhat arbitrarily; a standard normal random variable (zero mean, unit standard deviation) has a probability of .01 of being larger than 2.326. If the true value of all the FIR ratios is equal to the mean value, then sample cell estimates (such as those produced here) would be more than 2.326 standard errors larger than the mean approximately one percent of the time, i.e., out of 288 cells, the expected number is around 3 (approximately 2.88). There were actually 19 FIR ratios over 2.326 standard errors greater than the mean. Clearly there is a very high probability that the true FIR ratio for most of these 19 cells is different from the mean.

*These standard errors are given in Table 5.2.

If the 19 cells which are significantly less than the mean (by this definition) are each marked by a row of asterisks as in Table 5.3, the pattern they make shows that certain levels of some variables are more stongly and consistently associated with small ratio cells than others. The conditions most associated with the small ratio cells from Table 5.3 appear to be:

1. Young drivers (and to a lesser extent middle-aged drivers)
2. Urban driving
3. Only one occupant in vehicle

and to a lesser extent:

4. "Other" time period
5. Male drivers

If the same exercise is carried out on cells which have FIR ratios significantly higher than the mean, the 38 cells marked in Table 5.4 are identified. The conditions most associated with high FIR ratio cells appear to be:

1. Rural driving
2. Older and middle-aged drivers

and to a less extent:

3. More than one occupant in the vehicle
4. Vehicle over five years old

As a result of this analysis, the most promising single variables are Urban/Rural and Driver Age; both of which have strong effect and which have a consistent effect in that when you reverse the variable, the FIR ratio reverses. It appears that this effect may be somewhat independent of the other variables.

5.2 Examination of the Log-Linear Model

The log-linear model for the FIR ratio can be calculated from the log-linear model estimating the FARS fatal involvements by cell and the log-linear model estimating the NPTS VMT total by cell (both are described in Section 1.0). The fatal involvement rate, FIR, is the ratio of the FARS cell estimate to the NPTS cell estimate. Thus, log FIR = log FARS - log NPTS, which means that the terms in the log-linear model for the fatal involvement rate are obtained by

TABLE 5.3

FIR Ratios (Light/Heavy) Significantly Less than Mean

SEASON: SUMMER

LAND USE:				URBAN				RURAL			
VEHICLE AGE:				5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
VEHICLE WEIGHT:				RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.694030	------	0.668965	------	0.685428	------	0.772302	------
			26-55	0.976341	------	0.903631	------	1.123656	------	1.215591	------
			GE 56	0.970168	------	1.121986	------	1.529439	------	2.067053	******
		FEMALE	LE 25	0.693360	------	0.560333	------	0.710313	------	0.670846	------
			26-55	1.054655	------	0.818308	------	1.487617	******	1.348661	------
			GE 56	1.035873	------	1.003628	------	0.944476	------	1.069885	------
	RUSH	MALE	LE 25	0.946154	------	0.912014	------	0.934364	------	1.052740	------
			26-55	0.864271	------	0.798785	------	0.993881	------	1.074899	------
			GE 56	0.894420	------	1.034559	------	1.410476	------	1.906136	******
		FEMALE	LE 25	0.935247	------	0.755797	------	0.958368	------	0.905010	------
			26-55	0.923524	------	0.715562	------	1.301812	------	1.180578	------
			GE 56	0.945223	------	0.915684	------	0.862052	------	0.976253	------
	LATE	MALE	LE 25	0.877654	------	0.845971	------	0.866706	------	0.976560	------
			26-55	0.961294	------	0.889624	------	1.106322	------	1.196654	------
			GE 56	0.863184	------	0.998185	------	1.361615	------	1.840427	******
		FEMALE	LE 25	1.043225	------	0.842763	------	1.068500	------	1.009290	------
			26-55	1.234995	------	0.957835	------	1.742440	******	1.578791	******
			GE 56	1.096271	------	1.061639	------	0.998960	------	1.133843	------
MORE THAN ONE	OTHER	MALE	LE 25	0.718496	------	0.970025	------	0.709517	------	1.119709	------
			26-55	1.011424	------	1.310617	------	1.163429	------	1.762408	******
			GE 56	1.004557	------	1.626413	******	1.583132	------	2.997026	******
		FEMALE	LE 25	0.717891	------	0.812447	------	0.735388	------	0.972688	------
			26-55	1.091459	------	1.185984	------	1.540000	******	1.955422	******
			GE 56	1.072228	------	1.454964	------	0.977906	------	1.551202	------
	RUSH	MALE	LE 25	0.979579	------	1.322164	------	0.967339	------	1.526413	******
			26-55	0.894410	------	1.158389	------	1.028773	------	1.558577	******
			GE 56	0.926396	------	1.500124	------	1.459907	------	2.764329	******
		FEMALE	LE 25	0.968641	------	1.096126	------	0.992149	------	1.312077	------
			26-55	0.955556	------	1.037649	------	1.347444	------	1.711343	******
			GE 56	0.978523	------	1.328010	------	0.892185	------	1.416152	------
	LATE	MALE	LE 25	0.908614	------	1.226550	------	0.897273	------	1.415841	------
			26-55	0.995327	------	1.289758	------	1.145124	------	1.735028	******
			GE 56	0.893709	------	1.447375	------	1.408771	------	2.666458	******
		FEMALE	LE 25	1.080157	------	1.222237	------	1.106456	------	1.463020	------
			26-55	1.278440	------	1.388776	------	1.803132	******	2.289958	******
			GE 56	1.135115	------	1.541184	------	1.035569	------	1.639588	------

TABLE 5.3 (cont'd)
FIR Ratios (Light/Heavy) Significantly Less than Mean

SEASON: WINTER

LAND USE:				URBAN				RURAL			
VEHICLE AGE:				5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
VEHICLE WEIGHT:				RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.606305	------	0.584439	------	0.598717	------	0.674617	------
			26-55	0.852910	------	0.789360	------	0.981690	------	1.061808	------
			GE 56	0.847458	------	0.979952	------	1.335993	------	1.805702	******
		FEMALE	LE 25	0.824592	------	0.666227	------	0.844481	------	0.797535	------
			26-55	1.254069	------	0.972344	------	1.768624	******	1.603783	******
			GE 56	1.231231	------	1.193292	------	1.123096	------	1.272128	------
	RUSH	MALE	LE 25	0.826490	------	0.796677	------	0.816248	------	0.919614	------
			26-55	0.754200	------	0.697761	------	0.868157	------	0.939017	------
			GE 56	0.781565	------	0.903755	------	1.231818	------	1.665073	------
		FEMALE	LE 25	1.112476	------	0.898781	------	1.139482	------	1.075972	------
			26-55	1.097470	------	0.850900	------	1.547741	******	1.403327	------
			GE 56	1.123760	------	1.088991	------	1.024493	------	1.161132	------
	LATE	MALE	LE 25	0.766663	------	0.739035	------	0.757157	------	0.853160	------
			26-55	0.839766	------	0.777147	------	0.966367	------	1.045276	------
			GE 56	0.754004	------	0.871944	------	1.189074	------	1.604676	------
		FEMALE	LE 25	1.240217	------	1.002057	------	1.270112	------	1.199766	------
			26-55	1.468289	------	1.138777	------	2.070963	******	1.877515	******
			GE 56	1.302801	------	1.262426	------	1.190580	------	1.349300	------
MORE THAN ONE	OTHER	MALE	LE 25	0.627566	------	0.847373	------	0.619876	------	0.978133	------
			26-55	0.883045	------	1.144798	------	1.016539	------	1.539705	******
			GE 56	0.877240	------	1.420966	------	1.383404	------	2.618176	******
		FEMALE	LE 25	0.853495	------	0.965940	------	0.874275	------	1.156330	------
			26-55	1.297362	------	1.410061	------	1.831119	******	2.325104	******
			GE 56	1.274586	------	1.729886	------	1.162570	------	1.843956	------
	RUSH	MALE	LE 25	0.855602	------	1.155193	------	0.845069	------	1.333303	------
			26-55	0.781070	------	1.011888	------	0.898538	------	1.361378	------
			GE 56	0.809227	------	1.310464	------	1.275309	------	2.414610	******
		FEMALE	LE 25	1.151663	------	1.303191	------	1.179622	------	1.560047	------
			26-55	1.136071	------	1.234391	------	1.602906	******	2.034915	******
			GE 56	1.163539	------	1.578035	------	1.060799	------	1.683703	------
	LATE	MALE	LE 25	0.793730	------	1.071547	------	0.783937	------	1.237198	------
			26-55	0.869468	------	1.126692	------	1.000312	------	1.515512	******
			GE 56	0.780554	------	1.263812	------	1.230647	------	2.329792	******
		FEMALE	LE 25	1.283996	------	1.453064	------	1.315037	------	1.739115	------
			26-55	1.520025	******	1.650895	******	2.144829	******	2.722795	******
			GE 56	1.349092	------	1.830993	------	1.231490	------	1.957190	------

TABLE 5.4
FIR Fatios (Light/Heavy) Significantly Greater than Mean

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.694030	******	0.668965	******	0.685428	------	0.772302	------
			26-55	0.976341	------	0.903631	------	1.123656	------	1.215591	------
			GE 56	0.970168	------	1.121986	------	1.529439	------	2.067053	------
		FEMALE	LE 25	0.693360	------	0.560333	******	0.710313	------	0.670846	------
			26-55	1.054655	------	0.818308	------	1.487617	------	1.348661	------
			GE 56	1.035873	------	1.003628	------	0.944476	------	1.069885	------
	RUSH	MALE	LE 25	0.946154	------	0.912014	------	0.934364	------	1.052740	------
			26-55	0.864271	------	0.798785	******	0.993881	------	1.074899	------
			GE 56	0.894420	------	1.034559	------	1.410476	------	1.906136	------
		FEMALE	LE 25	0.935247	------	0.755797	------	0.958368	------	0.905010	------
			26-55	0.923524	------	0.715562	******	1.301812	------	1.180578	------
			GE 56	0.945223	------	0.915684	------	0.862052	------	0.976253	------
	LATE	MALE	LE 25	0.877654	------	0.845971	------	0.866706	------	0.976560	------
			26-55	0.961294	------	0.889624	------	1.106322	------	1.196654	------
			GE 56	0.863184	------	0.998185	------	1.361615	------	1.840427	------
		FEMALE	LE 25	1.043225	------	0.842763	------	1.068500	------	1.009290	------
			26-55	1.234995	------	0.957835	------	1.742440	------	1.578791	------
			GE 56	1.096271	------	1.061639	------	0.998960	------	1.133843	------
MORE THAN ONE	OTHER	MALE	LE 25	0.718496	******	0.970025	------	0.709517	------	1.119709	------
			26-55	1.011424	------	1.310617	------	1.163429	------	1.762408	------
			GE 56	1.004557	------	1.626413	------	1.583132	------	2.997026	------
		FEMALE	LE 25	0.717891	------	0.812447	------	0.735388	------	0.972688	------
			26-55	1.091459	------	1.185984	------	1.540000	------	1.955422	------
			GE 56	1.072228	------	1.454964	------	0.977906	------	1.551202	------
	RUSH	MALE	LE 25	0.979579	------	1.322164	------	0.967339	------	1.526413	------
			26-55	0.894410	------	1.158389	------	1.028773	------	1.558577	------
			GE 56	0.926396	------	1.500124	------	1.459907	------	2.764329	------
		FEMALE	LE 25	0.968641	------	1.096126	------	0.992149	------	1.312077	------
			26-55	0.955556	------	1.037649	------	1.347444	------	1.711343	------
			GE 56	0.978523	------	1.328010	------	0.892185	------	1.416152	------
	LATE	MALE	LE 25	0.908614	------	1.226550	------	0.897273	------	1.415841	------
			26-55	0.995327	------	1.289758	------	1.145124	------	1.735028	------
			GE 56	0.893709	------	1.447375	------	1.408771	------	2.666458	------
		FEMALE	LE 25	1.080157	------	1.222237	------	1.106456	------	1.463020	------
			26-55	1.278440	------	1.388776	------	1.803132	------	2.289958	------
			GE 56	1.135115	------	1.541184	------	1.035569	------	1.639588	------

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TABLE 5.4 (cont'd)
FIR Ratios (Light/Heavy) Significantly Greater than Mean (continued)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
OCCUPANTS	TIME	SEX	VEHICLE WEIGHT: AGE	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES	RATE	VARIABLES
ONE	OTHER	MALE	LE 25	0.606305	******	0.584439	******	0.598717	******	0.674617	******
			26-55	0.852910	******	0.789360	******	0.981690	------	1.061808	------
			GE 56	0.847458	------	0.979952	------	1.335993	------	1.805702	------
		FEMALE	LE 25	0.824592	------	0.666227	******	0.844481	------	0.797535	------
			26-55	1.254069	------	0.972344	------	1.768624	------	1.603783	------
			GE 56	1.231231	------	1.193292	------	1.123096	------	1.272128	------
	RUSH	MALE	LE 25	0.826490	------	0.796677	------	0.816248	------	0.919614	------
			26-55	0.754200	******	0.697761	******	0.868157	------	0.939017	------
			GE 56	0.781565	------	0.903755	------	1.231818	------	1.665073	------
		FEMALE	LE 25	1.112476	------	0.898781	------	1.139482	------	1.075972	------
			26-55	1.097470	------	0.850900	------	1.547741	------	1.403327	------
			GE 56	1.123760	------	1.088991	------	1.024493	------	1.161132	------
	LATE	MALE	LE 25	0.766663	******	0.739035	------	0.757157	------	0.853160	------
			26-55	0.839766	------	0.777147	******	0.966367	------	1.045276	------
			GE 56	0.754004	------	0.871944	------	1.189074	------	1.604676	------
		FEMALE	LE 25	1.240217	------	1.002057	------	1.270112	------	1.199766	------
			26-55	1.468289	------	1.138777	------	2.070963	------	1.877515	------
			GE 56	1.302801	------	1.262426	------	1.190580	------	1.349300	------
MORE THAN ONE	OTHER	MALE	LE 25	0.627566	******	0.847373	------	0.619876	******	0.978133	------
			26-55	0.883045	------	1.144798	------	1.016539	------	1.539705	------
			GE 56	0.877240	------	1.420966	------	1.383404	------	2.618176	------
		FEMALE	LE 25	0.853495	------	0.965940	------	0.874275	------	1.156330	------
			26-55	1.297362	------	1.410061	------	1.831119	------	2.325104	------
			GE 56	1.274586	------	1.729886	------	1.162570	------	1.843956	------
	RUSH	MALE	LE 25	0.855602	------	1.155193	------	0.845069	------	1.333303	------
			26-55	0.781070	------	1.011888	------	0.898538	------	1.361378	------
			GE 56	0.809227	------	1.310464	------	1.275309	------	2.414610	------
		FEMALE	LE 25	1.151663	------	1.303191	------	1.179622	------	1.560047	------
			26-55	1.136071	------	1.234391	------	1.602906	------	2.034915	------
			GE 56	1.163539	------	1.578035	------	1.060799	------	1.683703	------
	LATE	MALE	LE 25	0.793730	------	1.071547	------	0.783937	------	1.237198	------
			26-55	0.869468	------	1.126692	------	1.000312	------	1.515512	------
			GE 56	0.780554	------	1.263812	------	1.230647	------	2.329792	------
		FEMALE	LE 25	1.283996	------	1.453064	------	1.315037	------	1.739115	------
			26-55	1.520025	------	1.650895	------	2.144829	------	2.722795	------
			GE 56	1.349092	------	1.830993	------	1.231490	------	1.957190	------

subtracting the terms in the NPTS log-linear model from those in the FARS log-linear model.

The logarithm of the FIR ratio is then obtained by subtracting the log of the fatal involvement rate for heavy vehicles from that for light vehicles:

Log (FIR ratio) = Log FIR (light) - log FIR (heavy)

Now the terms which do not involve vehicle weight cancel between log FIR (light) and log FIR (heavy) while those terms which do involve weight are in FIR (heavy) with the same magnitude but opposite sign as the corresponding terms in FIR (light). Thus log (FIR ratio) = 2 * log FIR (retricted to terms involving vehicle weight), i.e., the log-linear model for the FIR ratio consists of the terms in the log-linear model of the fatal involvement rate which involve vehicle weight multiplied by a factor of 2.

The resulting terms are listed in Table 5.5. This table lists all coefficients in the log-linear model which are not redundantly determined by other coefficients. For each two-level variable in an interaction, the coefficient appropriate to the lower level (level 1) is listed and the coefficient appropriate to the upper level is obtained by multiplying by -1. For each three-level variable, the coefficients appropriate to the lowest level is listed first. Thus, the coefficient -.1584 in the 5-7 interaction corresponds to level 1 of both variable 5 and variable 7. The coefficient .0442 in the 3-6 interaction corresponds to level 1 for both variables 3 and 6. The coefficient .0196 in the 5-7 interaction corresponds to level 2 of variable 5 and level 3 of variable 7

The purpose of Table 5.5 is to give an idea of the relative magnitude of various lower order and higher order effects. Clearly, Driver Age and Urban/Rural are among the most influential single effects. Number of Occupants and Car Age are also influential. Note that there are strong interactions involving driver age, (2-7, 3-7, 5-7...) but these do not seem to completely overwhelm the main efect. Other variables such as Driver Sex and Time of Day have strong simple effects but enter into even stronger interactions. Even the strongest main effect can be swamped by a combination of high order interactions. This is consistent with the general picture that no single variable has a highly-consistent effect.

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Table 5.5
Log-Linear Model for FIR Ratio

Effect	Coefficients		
Main	.1168		
1 Season	-.0094		
2 U/R	-.1106		
3 Car age	-.0844		
4 # of Occupants	-.1016		
5 Time	-.0502	-.0202	.0704
6 Sex	-.0582		
7 Driver age	-.1832	+.0672	.1160
1-6	.077		
2-3	.039		
2-6	-.0256		
2-7	.0688	-.0496	-.0192
3-4	.0842		
3-6	.0442		
3-7	.0236	.0438	-.0674
5-6	.0272	.0324	-.0596
5-7	-.1584	.0694	.089
	.1162	-.089	-.0272
	.0422	.0196	-.0618
6-7	-.0108	-.0914	.1022
2-6-7	.0346	.0764	-.1112

5.3 Examination of Groups of Cells

The analysis to this point suggests that four variables have a strong relatively consistent effect:

1. Driver Age
2. Urban/Rural
3. Number of Occupants
4. Vehicle Age

The evidence for the variable Vehicle Age is not as strong as for the first three.

The last analysis will confirm these observations. The idea of this analysis is that if one fixes an important variable at a critical value, the average FIR ratio will be significantly different from before the variable is fixed and this will be true even when other variables are fixed at various levels. This can best be seen by a concrete example.

A particular cell is chosen (as the "target" cell) such as the cell with the largest (or smallest) FIR ratio. This determines a level for each variable. Now an ordering of the variables is chosen and in turn each variable is fixed at the chosen level and a weighted average of the FIR ratio over cells is taken. The weighted average is first taken over all cells, then over only those cells corresponding to the chosen level of the first variable,* then only those cells corresponding to the chosen levels of the first two variables, etc. until the final average is over just one cell, the one selected as the target cell (and so no average is needed).

The results of such a process will be referred to somewhat arbitrarily as a "tree". Table 5.6 shows three such "trees". This table is best explained by indicating the information given in some typical lines. The second line of data shows that the first variable to be fixed was variable 7, it was fixed to level 3 (older drivers).

*Here "first variable" is in the sense of some arbitrarily chosen ordering; this is not necessarily "variable 1" as referred to consistently in this report.

Analysis by Groups of Cells

Table 5.6
Three Trees Ending in Cell with Largest Ratio

Ratio	Log Ratio	# of Cells	Total Fatal Involvements	SE (over cells)	Summer 1	Rural 2	Old Cars 3	More than one Occupant 4	Other (time) 5	Male 6	Old Driver 7
1.059	.0567	288	37321	.0182							
1.348	.2989*	96	5602	.0355							3
1.539	.4311*	48	3236	.0528			2				
1.985	.6855*	24	1296	.0623			2	2			3
2.366	.8611*	12	800	.0734		2	2	2			3
2.732	1.0051*	6	572	.0364		2	2	2		1	3
2.910	1.0681	3	307	.0319	1	2	2	2	1	1	3
2.997	1.0976	1	212	---	1	2	2	2	1	1	3
1.059	.0567	288	37321	.0182							
1.348	.2989*	96	5602	.0355							3
1.416	.3479	48	4034	.0550						1	3
1.486	.3958	16	2520	.097					1	1	3
1.722	.5432*	8	1142	.150				2	1	1	3
2.243	.8077*	4	620	.176			2	2	1	1	3
2.818	1.0360*	2	390	.067		2	2	2	1	1	3
2.997	1.0976	1	212	---	1	2	2	2	1	1	3
1.059	.0567	288	37321	.0182							
1.094	.0898	144	19569	.0246	1						
1.201	.1835	72	11171	.0378	1	2					
1.326	.2820	36	6528	.0538	1	2	2				
1.535	.4284*	18	3461	.0672	1	2	2	2			
1.503	.4077	6	1699	.1578	1	2	2	2	1		
1.535	.4287	3	1256	.2568	1	2	2	2	1	1	
2.977	1.0976*	1	212	---	1	2	2	2	1	1	3

This level corresponded to 96 cells (96 = 288/3). The total number of estimated fatal involvements for these 96 cells was 5602 (this gives an idea of the statistical stability of an average of these cells); the standard error of the mean of the log of the FIR ratio over these 96 cells was .0355,* the weighted average (with fatal involvements as weighting factor) of the logarithm of the FIR ratio over these 96 cells was .2989; the anti-logarithm of .2989 is 1.348. The next line contains similar information about an average with the next variable (variable number 3) fixed to level number 2 (older cars). This left 48 cells and the weighted average of the logarithm of the FIR ratio over these 48 cells was .4311, etc.

Certain lines contain an asterisk after the logarithm of the FIR ratio. This indicates that this quantity changed by more than .1 from the previous line. This indicates that the variable first fixed on that line appears to be relatively important. The variables so identified in the three trees in this table (all three end at the cell with the largest FIR ratio 2.977) and in the tree in Table 5.7 (which ends at the smallest FIR ratio .5844) are as follows:

1. Driver Age, Car Age, Number of Occupants, Urban/Rural, Driver Sex
2. Driver Age, Number of Occupants, Car Age, Urban/Rural
3. Number of Occupants, Driver Age
4. Number of Occupants, Urban/Rural, Driver Age, Time Period

*This "standard error" is calculated as follows. Let L_i be the log of the FIR ratio for the ith cell and let W_i be the weight (this is, of course, the estimated fatalities for this cell), then $L = \sum W_i L_i / \sum_i W_i$, just as defined earlier, is the weighted mean over cells, then, $\sigma_L^2 = \sum_i (L_i - L)^2 W_i / \sum_i W_i$. The standard error in L is estimated as $\sigma / \sqrt{N}$. Here N is the total number of cells being used to find L. This process is the usual process for calculating a standard error for a mean. Even through the conditions for applying this process are not present, it is still of some value. The standard error in L gives an estimate of the instability of L due to the fact that it varies from cell to cell, both because of changing circumstances (from cell to cell) and because of sampling error. If the cell estimates were independent then the standard error in L would be an in upper-bound on the sampling error in L. Since the cell estimates are not independent (because of the log-linear modelling process) we no longer have an upper-bound in sampling error in this quantity. However, it may be used in conjunction with total fatalities to estimate the statistical stability of L.

Analysis by Groups of Cells

Table 5.7
One Tree Ending in Cell with Smallest Ratio

Ratio	Log Ratio	# of Cells	Total Fatal Involvements	SE (over cells)	Winter 1	Urban 2	Older Cars 3	One Occupant 4	Other (time) 5	Male 6	Young 7
1.0583	.0567	288	37321	.0182							
.9552	-.0458*	144	19799	.0220				1			
.8550	-.1567*	72	9669	.0213		1		1			
.7657	-.2670*	24	3703	.0361		1		1			1
.6436	-.4422*	8	1350	.0366		1		1	1		1
.6205	-.4772	4	816	.0425		1	2	1	1		1
.6038	-.5045	2	413	.0566	2	1	2	1	1		1
.5844	-.5371	1	310	---	2	1	2	1	1	1	1

Further analyses of this type of confirmed that the strongest and most consistent variables were:

1. Driver Age
2. Urban/Rural
3. Number of Occupants

and possibly,

4. Age of Car

5.4 Analysis Using Three Variables

Certain variables have an inconsistent effect (Driver Sex, Time of Day) or a weak effect (Season). But four variables have been identified as having a strong, consistent effect (although the fourth, Vehicle Age, is not as strong as the others). This section is concerned with characterizing how the fatal involvement rate ratio explicitly depends on three out of these four variables. The variable, Number of Occupants, will not be included since it is felt to be largely a crashworthiness connected factor: small cars are less crashworthy than large cars, therefore, more occupants in the car does more to make small cars more likley to have a fatal accident than it does to make large cars more likely.

The analysis comes down to three variables for explicit consideration:

1. Driver Age
2. Urban/Rural
3. Vehicle Age

The other five variables (including Number of Occupants) are controlled for. This is done taking weighted averages (weighting factor equal to fatal involvements) over groups of cells corresponding to specific levels for the three specified variables. The result is given in Table 5.8. For each combination of levels for the three variables the weighted average (over all cells with those characteristics) of the logarithm of the FIR ratio is given in rows labelled "(2)" (as indicated by the legend). The anti-logarithm of this number is given in the rows labelled "(1)". For example, looking at the top left corner of the table, young drivers in urban areas in newer cars are estimated to have only 82 percent

Analysis by Groups of Cells

Table 5.8
Examination of the Most Important Factors Affecting the FIR Ratio

		Young Drivers		Middle Age Drivers		Old Drivers	
		Newer Cars	Older Cars	Newer Cars	Older Cars	Newer Cars	Older Cars
Urban	(1)	.8200	.8936	.9703	.9625	.9440	1.1652
	(2)	-.1984	-.1125	-.0301	-.0382	-.0576	.1529
	(3)	-.3386	-.1503	-.1137	.0767	.0257	.2140
	(4)	2753	4518	3270	3518	1000	1456
	(5)	.0383	.0505	.0324	.0439	.0291	.0419
Rural	(1)	.8133	1.0631	1.9686	1.406	1.280	1.932
	(2)	-.2067	.0612	.1797	.341	.2467	.6586
	(3)	-.0779	.1104	.1493	.3376	.2864	.4747
	(4)	3710	5825	3712	4350	1366	1780
	(5)	.0330	.0489	.0486	.0515	.0356	.0625

(1) Ratio
(2) Log ratio
(3) Estimated log ratio - main effects model
(4) Total fatal involvements in cell
(5) Standard Error (over cells) of log ratio

(.82) as many fatal accidents (per VMT) in small cars as in large cars. On the other hand, older drivers in older cars in rural areas are estimated to have 93 percent more (1.932) fatal accidents in small cars than in large cars. The rows labelled "(4)" and "(5)" are for use in assessing the statistical stability of the estimates in the same way as described for Table 5.6 (they give total fatal involvements in the group and the standard deviation over cells withn the group of the logarithm of the FIR ratio). This table, although based on only three variables, is still too complex for easy comprehension. The dependence of the FIR ratio on these variables would be simple to describe and understand if it were according to a simple main effects model with no interactions. More specifically, assume a simple log-linear model -- that the FIR ratio is determined by three factors, one for each variable, i.e, the log of the FIR ratio is the sum of three terms each depending on only one of the variables. The results of fitting such a model (using linear modelling techniques on the log of the FIR ratio*) are shown in the rows labelled "(3)". The entries in the rows labelled "(3)" are to be compared to the corresponding entries in the rows labelled "(2)" (the logarithm of the FIR ratio) to see how well the model fits. The fit, although not exceptionally good, is satisfactory and indicates that the model estimates the FIR ratio in all conditions with at least "ball park" accuracy. When the model estimates high, the ratio is high, when the model estimates low, the ratio is low, when the model is between, so is the ratio. This analysis suggests that there is value in looking at the effect of the variables singly.

Table 5.9 shows the results of averaging over all variables but one when the variable not averaged over is each of the three selected variables in turn. This table is similar in content to the previous tables (Table 5.6 and Table 5.8). The column labelled "Log Ratio" gives the weighted average of the logarithm of the FIR ratio over all cells corresponding to the variable level (condition) specified in the last column. The first column gives the anti-logarithm of the second column; it gives the best estimate of the aggregate FIR ratio for the specified condition, controlling for the other variables.

*This differs from the log-linear model fitting algorithm for count data, but is suitable for this purpose.

Analysis by Groups of Cells

Table 5.9
Aggregate Effects of Three Main Variables

Ratio	Log Ratio	# of Cells	Total Fatal Involvements	SE (over cells)	Variable
.934	-.0679	144	16578	.0185	urban
1.170	.1566	144	20743	.0277	rural
.971	-.0294	144	15811	.0213	newer cars
1.128	.1204	144	21510	.0274	older cars
.916	-.0872	96	16806	.0254	young drivers
1.137	.1284	96	14913	.0278	middle age driver
1.348	.2989	96	5602	.0355	old drivers

The columns labelled "Total Fatal Involvements" and "S E (over cells)" are as usual for assessing statistical stability (ratio-based on more than 10,000 fatal involvements, with a "standard error over cells" of less than .03 should be statistically very stable). The conclusions to be drawn from Table 5.9 are these:

(1) In urban driving, small cars have about six to seven percent fewer fatal involvements per VMT in similar situations than do large cars;

(2) In rural driving, the comparison favors large cars by about 16 percent;

(3) For young drivers, small cars have about 9 prcent fewer fatal involvements (again, per VMT and controlling for other factors);

(4) For older drivers, small cars are 30 pecent worse than large cars according to this measure (fatalities per VMT controlling for other factors); and

(5) For newer cars, small cars may be about three percent better than large cars (this may not be statistically significant).

APPENDIX A

Development of FARS and NPTS Log-Linear Models

The log-linear models for the FARS and NPTS data were constructed using the LOGLIN computer package developed at the Harvard School of Public Health. In general, the method used for constructing the models is to start with the three sets of (1) all 28 two-way interactions (I-J), (2) all 56 three-way interactions (I-J-K), and (3) all 70 four-way interactions (I-J-K-L), select significant interactions from these sets to create a more parsimonious model, and continue a process of eliminating the weaker interactions and adding in stronger interactions until a satisfactory model is developed.

Interactions are eliminated (or added) on the basis of thresholds for $\Delta X^2/\Delta df$ (those interactions with $\Delta X^2/\Delta$ df lower than the threshold are dropped). Note, however, that higher order interactions draw in implied lower order interactions if the latter are not already in the model (for example, interaction I-J-K includes I, J, K, I-J, J-K, I-K). Therefore, when eliminating interactions on the basis of $\Delta X^2/\Delta df$ for a higher order interaction, provisions must be made for the dilution of strength ($\Delta X^2/\Delta df$) by implied lower order interactions not includable on the basis of their own $\Delta X^2/\Delta df$.

In developing these models, $\Delta X^2/\Delta df$ for each interaction was approximated using standardized effect estimates (effect coefficients divided by their standard error)* for the interactions in the final model. The results of this comparison indicate the approximations are exact for interactions of one degree of freedom but rough estimates of $\Delta X^2/\Delta df$ for interactions with multiple degrees of freedom.

The following is a description of the steps used to develop the FARS and NPTS models. For both the FARS and NPTS data:

*The estimate used was $\Delta X^2/\Delta df = (\sum_{i=1}^{K} E_i^2)/K$ where E_i is the value of the i^{th} standardized effect coefficient and K is the number of such coefficients for the given interactions.

1. Calculate the standardized effects estimates for models based on the sets of all 28 two-way interactions (1-2, 1-3, 1-4,... 7-8), all 56 three-way interactions (1-2-3, 1-2-4, ..., 6-7-8) and all 70 four-way interactions (1-2-3-4, 1-2-3-5, ..., 5-6-7-8). Table A.1 summarizes the results of fitting the models.

   Note 1: A similar run of all 8 one-way ineractions (1, 2, 3, 4, 5, 6, 7, 8) was not done, as it was decided all would be included in the final model (all one-way interactions were strong at each stage of model development).

   Note 2: All four-way interactions were fit to the NPTS data (originally scaled by 10^5), then the data was scaled such that the resulting X^2 = df:

$$\frac{X^2}{\text{scaling factor}} = \text{df}$$

$$\frac{118493}{\text{scaling factor}} = 263$$

   scaling factor = 450.54

   The scaled data was then used to develop the model, including the initial runs of all two, three, and four-way interactions.

2. Construct a model consisting of all interactions from these three runs with an estimated $X^2/$ df greater than 2.5.

   Example calculation:
   Standardized effect estimate, interaction 4-5, FARS data, four-way run.

	DIM.5*		
DIM.4*	(1)	(2)	(3)
(1)	-10.31	7.81	.65
(2)	10.31	-7.81	-.65

*The variables are associated with numbers in Table A-7. Variable 5 is "Time" and variable 4 is "Occupants."

TABLE A.1: Results of Fitting the FARS and NPTS Data to the Models Consisting of All Two, Three and Four-Way Interactions

FARS:

	X^2	df	P*
two ways	907.29	522	$.33 \times 10^{-22}$
three ways	462.69	418	.065
four ways	270.41	263	.36

NPTS (data scaled by 10^5, divided by 450.54):

	X^2	df	P
two ways	840.05	522	$.29 \times 10^{-16}$
three ways	473.65	418	.031
four ways	263.00	263	.49

Estimated $\Delta X^2/\Delta df =$

$$((-10.31)^2 + (7.81)^2 + (.65)^2 + (10.31)^2 + (-7.81)^2 + (.65)^2)/6$$

$$= 55.90$$

Note: At this step, the weakening of the standardized effects estimates by weak implied lower order interactions was ignored. The ignoring of dilution effects at an early stage is a conservative convenience as it retains more interactions than necessary.

3. The models constructed from the strong interactions were fitted to the two data sets. The results are shown in Table A.2.

*P is the probability of getting a chi square value as large as or larger than that reported (in column labelled X^2) if the data arose from a process in which the specified model were accurate, i.e. according to a binomial (or poisson) distribution over cells with each cell probability proportional to the model predicted frequency.

TABLE A.2: Fit Resulting from Strong Interactions in Two, Three and Four-Way Runs

	X^2	df	P
FARS	414.05	429	.69
NPTS	390.98	396	.56

4. The estimated $\Delta X^2/\Delta df$ for the interactions in these models were calculated. From these results, new models were constructed using a 2.0 threshold, including the dilution of ΔX^2 by implied weak lower order interactions.

5. These new models were fitted to the data sets. The results are shown in Table A.3:

TABLE A.3: Results of Fitting Models Developed Using a 2.0 Threshold for X^2/ df

	X^2	df	P
FARS	490.20	480	.36
NPTS	497.29	463	.13

6. Step 4 was repeated using a 2.5 threshold for X^2/ df on the latest models. The results are shown in Table A.4.

TABLE A.4: Results of Fitting Models Developed Using a 2.5 Threshold for X^2/ df

	X^2	df	P
FARS	494.14	482	.34
NPTS	544.66	485	.031

7. Step 4 was repeated using a 3.0 threshold for $\Delta X^2/\Delta df$ on the latest models. The results are shown in Table A.5.

Note: For the NPTS model, there was no change (all interactions included in the previous run at the 2.5 threshold had estimated $\Delta X^2/\Delta df$ 3.0)

TABLE A.5 Results of Fitting Models Developed Using a 3.0 Threshold for X^2/ df

	X^2	df	P
FARS	498.01	483	.31
NPTS	544.66	485	.031

8. At this step, the models were examined and the original runs of all two, three and four-way interactions were searched for potentially significant interactions to be 'readded' to the model for a 'second chance.' In the NPTS model, all but 3 two-way interactions were already included, hence these three were retried. Likewise with the FARS model, all but 4 were included, hence these were retried. Additionally, any three or four-way interactions with an estimated $\Delta X^2/\Delta df$ greater than 2.5, not diluted, were retested (five and eight respectively for the FARS data and three and nine respectively for the NPTS data).

   These interactions were added to the respective models, one at a time, and the actual $\Delta X^2/\Delta df$ was calculated, including implied lower order interactions. With the NPTS model, one two-way, one three-way and one four-way were significant ($\Delta X^2/\Delta df > 3.0$), hence added to model. With the FARS model, none were significant.

9. Next, for interactions in each model that had estimated X^2/ df (diluted) close to 3.0, the actual $\Delta X^2/\Delta df$ was calculated. Those less than 3.0 were eliminated (this included one three-way from the NPTS model and a one-way and a four-way from the FARS model).

10. These final models were fitted to the data and the actual $\Delta X^2/\Delta df$ values were calculated. No higher order interactions, including dilution, were less than 3.0. Table A.6 shows the results of fitting these final models to the FARS and NPTS data. Table A.7 lists the interactions included in each model. (Note that Table A.7 refers to the interactions by number and also indicates which variables correspond to each number.)

TABLE A.6 Results of Fitting Final Models to FARS and NPTS Data

	X^2	df	P
FARS	508.24	489	.26
NPTS	514.88	479	.12

Note that the large P values with the given number of degrees of freedom strongly indicate that the models were not underfit.* The P value is the probability of getting so large a chi square if there were no underfit bias. Even a small bias will tend to make P quite small with so many degrees of freedom. As noted in Section 3.1, it was intended that the models not be underfit in order that any inaccuracy be due to sampling error and not to bias.

*Of course the strength of this indication is limited by the fact that the X^2 value on which P is based is artificially constructed in the case of the NPTS data.

TABLE A.7 Interactions in Final FARS and NPTS Models (Implied Lower Order Interactions Not Listed Separately)

FARS	NPTS	
3-4-6-7	3-4-6-7	
2-6-7, 6-7-8	2-6-7-8	
2-3-7	2-3-4-7	
2-3-6	2-3-6	
1-2-7	1-2-7	Commonality
4-5-6	4-5-6	
3-7-8	3-7-8	
1-3	1-3	
1-4	1-4	
2-4-5	5-7-8	
4-5-7	2-5-7	
1-2-5	2-4-6	
1-5-6	2-3-8	
5-6-8	1-6-8	
5-6-7	3-4-8	
	3-6-8	
	1-6-7	

Legend:

Variable Number:	Variable Name:
1	Season
2	Urban/Rural
3	Model Year
4	Occupants (one/more than one)
5	Time
6	Sex of Driver
7	Age of Driver
8	Weight of Vehicle

APPENDIX B

Empirical Test of Using Standardized Effect Estimates as a Proxy for $\Delta X^2/\Delta df$

The following tables show the actual $\Delta X^2/\Delta df$ and the estimated $\Delta X^2/\Delta df$ for the interactions in the final FARS and NPTS models (except the implied one- and two-way interactions). The estimated $\Delta X^2/\Delta df$ were computed from the standardized effects estimates from the final models as described in Appendix A. The actual $\Delta X^2/\Delta df$ were calculated by eliminating one interaction at a time from the model and calculating the resulting fit.

The implied two-way interactions were not tested because virtually all were included in the models, either on their own or because they were in several higher order interactions. Therefore, if a three-way interaction was eliminated, all two-way interactions were retained so only the three-way interaction was tested. The three-way interactions implied in the four-way interactions were tested however. They give an indication of the accuracy of the estimates for implied lower order interactions. (Not all implied three-ways were tested in the NPTS model because there were so many.) In the case of the implied three-way interactions which were tested, the actual $\Delta X^2/\Delta df$ is based on the difference between the chi square without the four-way interactions but all implied three-ways retained and the chi square without the four-way and three-way being tested. In other words, the base model in the case of these interactions is the full model minus the four-way interaction itself.

TABLE B.1

Results of Test on FARS Model

INTERACTIONS ELIMINATED**	X^2	df	$\Delta X^2/\Delta df$ ESTIMATED	$\Delta X^2/\Delta df$ ACTUAL
None	508.24	489	--	--
3-4-6-7	525.17	491	8.71	8.47
*3-4-6-7,3-4-6	525.17	492	1.69	0
*3-4-6-7,3-4-7	549.69	493	3.51	12.26
*3-4-6-7,3-6-7	551.19	493	14.23	13.01
*3-4-6-7,4-6-7	554.75	493	14.65	14.79
2-6-7	515.97	491	3.95	3.87
6-7-8	524.08	491	5.90	7.92
2-3-7	519.37	491	4.79	5.57
2-3-6	520.97	490	12.74	12.73
1-2-7	519.67	491	4.33	5.72
4-5-6	518.39	491	5.38	5.08
3-7-8	555.03	491	25.95	23.40
2-4-5	556.68	491	20.92	24.22
4-5-7	587.10	493	14.94	19.72
1-2-5	517.68	491	5.56	4.72
1-5-6	517.62	491	5.23	4.69
5-6-8	518.04	491	4.77	4.90
5-6-7	524.45	493	3.87	4.05
1-3	517.35	490	9.12	9.11
1-4	525.29	490	17.06	17.05

*Actual $\Delta X^2/\Delta df$ as compared to fit with the higher order four-way eliminated.
**Note: The variables are referred to by the numbers associated with them in Table A-7.

TABLE B.2

Results of Test on NPTS Model

INTERACTIONS ELIMINATED*	X^2	df	$\Delta X^2/\Delta df$ ESTIMATED	$\Delta X^2/\Delta df$ ACTUAL
None	514.88	479	---	---
2-3-4-7	525.79	481	4.54	5.46
*2-3-4-7,2-3-4	526.91	482	4.28	1.12
*2-3-4-7,2-4-7	531.08	483	3.19	2.65
2-6-7-8	523.45	481	5.08	4.29
*2-6-7-8,2-6-7	526.13	483	3.41	1.34
*2-6-7-8,6-7-8	545.12	483	10.95	10.84
*2-6-7-8,2-7-8	530.67	483	2.5	7.22
3-4-6-7	522.49	481	4.01	3.81
*3-4-6-7,3-4-6	527.89	482	12.39	5.4
*3-4-6-7,3-6-7	532.42	483	3.37	4.97
*3-4-6-7,4-6-7	582.91	483	29.34	27.51
5-7-8	538.93	483	3.12	6.01
3-4-8	535.20	480	20.25	20.32
1-6-8	531.72	480	16.81	16.84
1-2-7	525.90	481	5.48	5.51
2-3-6	518.75	480	3.88	3.87
2-3-8	518.92	480	4.04	4.04
2-4-6	525.31	480	10.43	10.43
2-5-7	527.37	483	3.94	3.12
3-7-8	522.72	481	3.63	3.92
1-6-7	526.54	481	5.97	5.83
4-5-6	543.85	481	9.19	14.49
3-6-8	520.21	480	5.34	5.33
1-4	548.47	480	33.52	33.59
1-3	543.62	480	28.73	28.74

*Acutual $\Delta X^2/\Delta df$ as compared to fit with the higher order four-way eliminated.
**Note: The variables are referred to by the numbers associated with them in Table A-7.

The results of these tests show that the estimates are exact for interactions with one degree of freedom but rough approximations for interactions with multiple degrees of freedom. Even so, the estimates appear to give valid indications of the actual $\Delta X^2/\Delta df$ for interactions with multiple degrees of freedom. Of the 17 interactions with multiple degrees of freedom in the FARS model, the estimates overstated the actual $\Delta X^2/\Delta df$ eight times, and understated it nine times. Only three estimates were off by more than 33%. With the 17 in the NPTS model (with multiple degrees of freedom), 10 estimates were overstated and 7 understated. Only six estimates were off by more than one-third.

Since there was no systematic bias, this indicates the reasonableness of the method, as does the tendency for the estimates to be close to the actual $\Delta X^2/\Delta DF$.

APPENDIX C

Log Linear Modelling Assumptions

This appendix considers the assumptions involved in applying classical log-linear modelling techniques to the NPTS and FARS data sets used in this study which do not strictly satisfy the classical requirements for applying log-linear models.

The FARS case will be treated first. The classical conditions are that the cell counts can be taken as independently distributed and Poisson distributed. These conditions are expected to hold for accidents classified by a set of variables but in the case of accident involvements (as in the FARS data matrix), each two-car accident leads to two involvements which contribute to two (possibly different) cells. This leads to the cell counts not being independent and not being Poisson distributed. However, if there are very many cells and no one cell has an appreciable probability to contain any one randomly chosen involvement, then both conditions should hold approximately. This is to say that in the case of very many cells none containing an appreciable fraction of all involvements, the cell counts should be approximately independent and Poisson distributed and this approximation should approach perfection as the fraction in the largest cell approaches zero. Since there are 576 cells in the present case and the cell containing the most involvements contains only about 2 percent of the total, it appears to be justified to treat the cell counts as satisfying the classical conditions for log-linear modelling. Furthermore, about half the involvements are single car and may be assumed independent and Poisson (per cell) from the outset. Thus, in the FARS case the classical requirements are approximately met and it is assumed that the degree of approximation is sufficient for the present purposes.

In the NPTS case the classical requirements for log-linear modelling are not satisfied to the degree needed for direct application of the method. The cell data are sums of VMT, a continuous measure, rather than counts as required. The use of log-linear models in this case is discussed in Reference 1 (Section 3.2.4). It is concluded there that the classical approach works well except that the chi square measure used for model selection is not valid. It is suggested that the chi square statistic may be approximately valid when properly scaled. The scaling factor involved can be applied instead to the raw data allowing it to be treated as true (Poisson distributed) count data from that point on. In order for the chi square statistic on the scaled data to be valid some rather strong conditions on the original data are needed. However, if the scaled chi square is all that is available for model selection then it seems appropriate to use it for this purpose. That is the current circumstance and so a scaled chi square is used for model selection in the case of the NPTS data.

An estimate of the proper scale factor is obtained in a different manner from that suggested in Reference 1. For this study the scale factor was obtained by making use of the fact that for high enough order models the expected chi square and the (residual) degrees of freedom are equal. Since (for the NPTS data) a hierarchical model fitting all fourth order interactions (as well as all lower order interactions) has a residual degrees of freedom of 263, it is to be expected that its chi square value should be approximately equal to 263. (For the FARS data the value of X^2 was 270 for all four-way interactions, very close to 263.) The data values (cell VMT sums) were scaled so that the usual chi square calculation produced a value of 263 for this model (all four factor interactions). The resulting scaled data behaved very much (in terms of chi square values for various models) like the true count data in the FARS matrix and this is taken as further evidence that the procedure of scaling the data and then using it as though it were count data is a satisfactory means of applying log-linear modelling techniques to the NPTS data.

APPENDIX D

It is noted in Appendix A that the log linear model fit to the VMT matrix does not appear to be under fit. This is based on the X^2 and degrees of freedom for the model.*

A more parsimonious (i.e. simpler) model is expected to have a lower standard error of estimate but also a higher bias. But, if the original model is substantialy overfit, then a more parsimonious model would be expected to have a lower overall error (consisting of the components bias and standard error). The question arises whether a more parsimonious model might have lower standard errors of estimates and also have a low enough bias that the overall accuracy would be increased. A more parsimonious model would also have the advantage of simplicity.

By producing a more parsimonious model and examining both the change in cell estimates and the change in standard errors, a better idea of whether the original model could have its error reduced by simplifying could be obtained.

A more parsimonious model was produced for these reasons. The terms in the more parsimonious model, its chi square value and its degrees of freedom are given in Table D.1. It was developed by techniques similar to those described for the original model in Section 3.2 and Appendix A. The final threshold value for $\Delta X^2/\Delta DF$ was 6, twice as high was for the original model.

*The X^2 value had to be calculated on the basis of a scaling of uncertain validity, but the assertion that the model was not underfit is supported by the fact that the standard errors of terms in the log-linear model for the VMT estimates were on the average about 2 times as large when calculated using sample splitting techniques as when calculated from the standard error estimates of the LOGLIN program (based on the scaling described in Appendix A). Since LOGLIN underestimated the variance this suggests that there would have been a tendency to overfit. In the case of the fatal involvement model, the two estimates of the standard error were consistently much closer (usually within 20 percent of each other). These observations are based on samples of 10 model parameters in both cases.

An examir estimated cell variances for the two models (see Section 4) and of the diffne cell estimates will give some indications of how the accuracy of the mdous model compares to that of the original model. Define four sums as fc

S_1 =ariances for the original model.

S_2 =ariances for the new model.

S_3 =e, the reduction in variance obtained by the new model.

S_4 =he squares of the differences in cell estimates.

Thus, S_4 in of bias although the difference is not due to bias alone but has a componss as well.

The valuentities are as follows:

1. $\sum_{cel} = S_1$
2. $\sum_{cel} = S_2$
3. $\sum_{cel} 7.7 = S_3$
4. $\sum_{cel}$ ate$)_A$ - (cell estimate$)_B)^2 = 11.7 = S_4$

where tl refers to the original model and the subscript B refers to the second nous model. Thus, the first number, 21.1, is an aggregate measure of the stability or noise in the first model and 13.4 is the corresponding measurend model. There is clearly a substantial improvement in this regard.

The fou.7, is the sum of two components. One is the sum of the squares of the das, i.e., a measure of increased bias of the second model over the first. 'onent is a measure of the noise in the difference in cell estimates betweedels. Unfortunately, the latter quantity cannot be directly estimatumbers given here and so the measure of the bias cannot be estimat Clearly 11.7 is an upper bound on the increased bias sum of squares not a very tight bound. These quantities could be estimated by returni samples to get estimates of the variances in the differences betwees. In the absense of this (not done to save time and money), one may try to get another estimate of this variance. Let C_A denote a cell estimate of model A and C_B the corresponding estimate of model B. Then:

$$\sigma^2_{(C_A - C_B)} = \sigma_A^2 + \sigma_B^2 - 2\sigma_{AB}$$

Now σ_{AB} is the covariance of the two estimates. It seems reasonable to assume that

$$0 \le \sigma_{AB} \le \sigma_B^2$$

If this is so

$$\sigma^2_{(C_A - C_B)} \ge \sigma_A^2 - \sigma_B^2$$

Since*

$$E\left(\sum_{cells} (C_A - C_B)^2\right) = \sum_{cells} (\Delta\, bias)^2 + \sum_{cells} \sigma^2_{(C_A - C_B)}$$

we have

$$\sum_{cells} (\Delta\, bias)^2 \le E\left[\sum_{cells} (C_A - C_B)^2 - (\sigma_A^2 - \sigma_B^2)\right]$$

$$\approx 11.7 - 7.7 = 4.0$$

Thus, 4.0 is the corresponding upper bound estimate of the increase in bias sum of squares. This is fairly small compared with the variance sum of squares of the second model, 13.4. The bias in the first model having nearly twice as many independent parameters (576 - 479 = 97 vs. 576 - 523 = 53) should be smaller than the change in bias. Therefore, this is more evidence that the first model had low bias.

Although these arguments are not rigorous, it appears that the second model may have a slightly smaller total aggregate error sum of squares, 13.44 + 4.0   21.1, but this is offset by the fact that the first model has a more accurate estimate of its total error, namely the statistical standard error in Table 4.2 since the bias is thought to be small.

In summary, the second model may be used when simplicity is desired and it probably is slightly more accurate. However, the first model should be used if it is important to have a good estimate of the accuracy.

The first model is used for all the analyses in the rest of this report. Tables for the second (more parsimonious) model corresponding to Tables 3.4, 3.5, 4.2, and 4.3 for the original model are given in this Appendix as Table D.2, D.3, D.4, and D.5 respectively.

* "E( )" denotes expected value. The expected value of a quantity summed over cells is well estimated by the observed value.

As already noted, the more parsimonious model is thought to be slightly more accurate than the original model but all standard errors referring to cell estimates or derived quantities (including fatal involvement rates) are less reliable indicators of accuracy than the corresponding standard errors for the original model.

Table D.1: Second Model for VMT

DF = 523

X^2 = 675.84*

Effects

168

246

347

348

456

467

678

13

14

25

28

36

57

*Scaled as indicated in Appendix A.

3.4N

Table D.2: Smoothed Estimates of Vehicle Miles Traveled (New Model) (Billions) (continued)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	2.007383	2.251958	1.746434	1.712514	0.809314	1.145253	0.704108	0.870914
			26-55	4.098405	8.156985	3.142508	5.466923	1.652349	4.148307	1.266961	2.780252
			GE 56	0.698719	2.305391	0.641412	1.849827	0.281702	1.172427	0.258597	0.940746
		FEMALE	LE 25	1.821369	1.842241	1.435820	1.269405	0.755147	0.963462	0.595297	0.663878
			26-55	2.327693	5.967643	1.617212	3.624065	0.965071	3.120979	0.670503	1.895326
			GE 56	0.519527	1.511339	0.432138	1.098825	0.215398	0.790406	0.179166	0.574667
	RUSH	MALE	LE 25	2.003474	2.247573	1.743034	1.709180	0.681828	0.964849	0.593195	0.733725
			26-55	4.611781	9.178749	3.536146	6.151723	1.569495	3.940299	1.203432	2.640842
			GE 56	0.523479	1.727195	0.480545	1.385888	0.178152	0.741459	0.163541	0.594941
		FEMALE	LE 25	1.504171	1.521407	1.185766	1.048333	0.526423	0.671642	0.414989	0.462798
			26-55	2.167330	5.556512	1.505797	3.374390	0.758513	2.452984	0.526992	1.489662
			GE 56	0.322070	0.936924	0.267895	0.681194	0.112717	0.413616	0.093757	0.300721
	LATE	MALE	LE 25	0.810926	0.909728	0.705510	0.691807	0.269862	0.381880	0.234782	0.290403
			26-55	1.095835	2.181021	0.840246	1.461750	0.364675	0.915535	0.279619	0.613604
			GE 56	0.103534	0.341605	0.095042	0.274101	0.034454	0.143397	0.031628	0.115060
		FEMALE	LE 25	0.401451	0.406051	0.316471	0.279791	0.137385	0.175284	0.108303	0.120780
			26-55	0.339578	0.870595	0.235928	0.528700	0.116211	0.375819	0.080740	0.228229
			GE 56	0.042002	0.122187	0.034937	0.088836	0.014374	0.052746	0.011956	0.038349
MORE THAN ONE	OTHER	MALE	LE 25	1.619614	1.905515	1.071660	1.560354	1.307116	1.939856	0.864888	1.588474
			26-55	3.942071	8.228298	2.084950	5.385752	3.181464	8.376585	1.682667	5.482812
			GE 56	1.044056	3.612738	0.472942	2.025284	0.842609	3.677846	0.381690	2.061783
		FEMALE	LE 25	1.112742	1.180358	0.667144	0.875798	0.713461	0.954650	0.427756	0.708328
			26-55	1.863601	5.010729	0.893108	2.971783	1.194893	4.052577	0.572638	2.403518
			GE 56	0.282478	0.861805	0.115944	0.437762	0.181117	0.697011	0.074340	0.354053
	RUSH	MALE	LE 25	0.493176	0.580233	0.326323	0.475131	0.335976	0.498613	0.222308	0.408295
			26-55	1.353364	2.824882	0.715791	1.848999	0.921981	2.427514	0.487633	1.588906
			GE 56	0.238648	0.825790	0.108104	0.462934	0.162579	0.709629	0.073646	0.397815
		FEMALE	LE 25	0.430592	0.456757	0.258161	0.338903	0.233048	0.311831	0.139724	0.231372
			26-55	0.813063	2.186112	0.389651	1.296548	0.440053	1.492475	0.210890	0.885163
			GE 56	0.082054	0.250336	0.033679	0.127161	0.044410	0.170906	0.018228	0.086814
	LATE	MALE	LE 25	0.415541	0.488894	0.274953	0.400336	0.276815	0.410814	0.183162	0.336400
			26-55	0.669430	1.397304	0.354060	0.914592	0.445946	1.174145	0.235859	0.768525
			GE 56	0.098255	0.339991	0.044508	0.190597	0.065453	0.285692	0.029649	0.160158
		FEMALE	LE 25	0.192311	0.203997	0.115300	0.151361	0.101778	0.136185	0.061021	0.101046
			26-55	0.213178	0.573179	0.102163	0.339943	0.112822	0.382643	0.054068	0.226940
			GE 56	0.017907	0.054632	0.007350	0.027751	0.009477	0.036471	0.003890	0.018526

5.5A

Table D.3: Fatal Involvement Rates
(Smoothed Based on New Model)
(Fatal Involvements Per Billion VMT)

SEASON: SUMMER

LAND USE:				URBAN				RURAL			
VEHICLE AGE:				5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
VEHICLE WEIGHT:				LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	38.26	48.57	59.05	92.68	125.18	125.97	188.61	234.71
			26-55	24.13	27.26	33.14	39.19	60.43	54.14	93.15	87.31
			GE 56	40.63	41.91	83.37	66.31	117.18	95.83	230.42	145.28
		FEMALE	LE 25	18.85	25.97	25.72	43.82	57.25	62.53	64.09	86.56
			26-55	15.64	16.71	20.01	22.37	40.15	34.01	48.44	42.94
			GE 56	24.38	31.23	47.77	47.15	78.65	79.85	124.06	97.09
	RUSH	MALE	LE 25	17.45	20.66	26.93	39.43	61.93	58.13	93.31	108.31
			26-55	9.46	9.97	12.99	14.33	25.70	21.47	39.61	34.63
			GE 56	23.16	22.29	47.54	35.26	72.46	55.28	142.50	83.80
		FEMALE	LE 25	12.06	15.66	16.46	26.42	39.73	40.90	44.48	56.61
			26-55	9.59	9.65	12.27	12.93	26.69	21.31	32.21	26.90
			GE 56	15.58	18.80	30.52	28.39	54.51	52.15	85.97	63.41
	LATE	MALE	LE 25	140.83	180.01	217.31	343.50	523.14	530.12	788.21	987.74
			26-55	92.15	104.86	126.60	150.74	262.10	236.45	404.00	381.35
			GE 56	82.44	85.65	169.19	135.50	270.01	222.39	530.95	337.12
		FEMALE	LE 25	81.52	95.08	111.22	160.41	281.12	259.92	314.69	359.81
			26-55	75.41	68.22	96.50	91.34	219.87	157.68	265.26	199.05
			GE 56	60.17	65.22	117.83	98.48	220.36	189.35	347.53	230.25
MORE THAN ONE	OTHER	MALE	LE 25	33.66	40.74	81.09	85.73	89.38	85.76	210.27	176.22
			26-55	13.15	14.17	25.57	20.36	26.74	22.84	58.33	36.82
			GE 56	17.36	17.08	54.40	29.14	40.65	31.70	122.05	51.83
		FEMALE	LE 25	25.61	33.64	44.20	50.72	81.72	85.09	115.73	105.26
			26-55	12.94	13.19	25.32	19.06	34.91	28.20	64.40	38.44
			GE 56	22.11	27.00	93.34	62.06	74.93	72.53	254.72	134.25
	RUSH	MALE	LE 25	28.89	32.61	69.61	68.63	84.80	75.89	199.51	155.95
			26-55	9.63	9.68	18.73	13.91	21.65	17.25	47.23	27.81
			GE 56	23.07	21.17	72.28	36.11	59.70	43.42	179.25	70.99
		FEMALE	LE 25	21.75	26.93	37.55	40.60	76.72	75.30	108.66	93.15
			26-55	10.45	10.04	20.45	14.52	31.18	23.74	57.51	32.35
			GE 56	23.22	26.72	98.03	61.43	86.99	79.36	295.71	146.89
	LATE	MALE	LE 25	250.54	305.36	603.66	642.64	561.18	542.23	1320.24	1114.22
			26-55	70.80	76.82	137.64	110.37	121.42	104.44	264.84	168.36
			GE 56	47.43	46.99	148.62	80.17	93.66	73.56	281.23	120.26
		FEMALE	LE 25	157.85	175.54	272.45	264.64	424.82	374.53	601.64	463.29
			26-55	61.98	53.47	121.26	77.30	141.05	96.45	260.16	131.48
			GE 56	51.75	53.49	218.49	122.96	147.89	121.20	502.79	224.47

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Table D.3: Fatal Involvement Rates
(Smoothed Based on New Model)
(Fatal Involvements Per Billion VMT)
(continued)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	36.96	54.06	63.97	115.72	96.74	112.18	163.50	234.46
			26-55	22.27	29.00	34.32	46.76	52.09	53.78	90.07	97.29
			GE 56	39.34	46.77	90.56	83.00	98.95	93.26	218.25	158.58
		FEMALE	LE 25	20.78	23.76	31.80	44.96	50.48	45.77	63.39	71.06
			26-55	16.47	14.61	23.64	21.94	39.49	27.77	53.44	39.32
			GE 56	26.94	28.64	59.20	48.51	75.78	63.86	134.07	87.10
	RUSH	MALE	LE 25	17.23	23.51	29.82	50.31	57.74	62.45	97.58	130.51
			26-55	8.92	10.84	13.75	17.48	26.72	25.73	46.20	46.55
			GE 56	22.93	25.42	52.77	45.11	73.82	64.89	162.82	110.35
		FEMALE	LE 25	16.17	17.43	24.75	32.98	50.30	42.98	63.16	66.73
			26-55	12.28	10.26	17.62	15.42	37.69	24.98	51.01	35.37
			GE 56	20.94	20.98	46.00	35.53	75.39	59.88	133.39	81.67
	LATE	MALE	LE 25	125.39	184.70	217.03	395.34	368.17	429.92	622.22	898.53
			26-55	78.41	102.82	120.83	165.79	205.74	213.89	355.73	386.95
			GE 56	73.60	88.11	169.41	156.36	207.64	197.07	458.01	335.11
		FEMALE	LE 25	81.08	78.50	124.09	148.56	221.00	169.62	277.50	263.39
			26-55	71.68	53.83	102.89	80.84	192.80	114.78	260.92	162.53
			GE 56	60.00	53.98	131.81	91.45	189.30	135.02	334.89	184.18
MORE THAN ONE	OTHER	MALE	LE 25	35.95	50.14	97.17	118.37	76.39	84.47	201.59	194.69
			26-55	13.43	16.67	29.28	26.87	25.49	25.09	62.37	45.37
			GE 56	18.60	21.08	65.36	40.34	37.96	34.12	127.86	62.56
		FEMALE	LE 25	31.21	34.03	60.43	57.55	79.69	68.88	126.59	95.58
			26-55	15.07	12.75	33.08	20.67	37.97	25.46	78.57	38.93
			GE 56	27.01	27.38	127.93	70.61	79.84	64.16	304.44	133.20
	RUSH	MALE	LE 25	31.54	41.03	85.24	96.85	87.43	90.17	230.73	207.84
			26-55	10.05	11.64	21.92	18.76	24.90	22.86	60.92	41.34
			GE 56	25.25	26.70	88.75	51.09	67.26	56.38	226.52	103.38
		FEMALE	LE 25	32.25	33.14	67.43	56.04	107.42	87.51	170.64	121.42
			26-55	14.81	11.81	32.50	19.15	48.69	30.77	100.73	47.05
			GE 56	34.51	32.97	163.43	85.01	133.08	100.78	507.46	209.24
	LATE	MALE	LE 25	246.71	346.51	666.78	817.98	436.78	486.34	1152.64	1120.98
			26-55	66.63	83.31	145.29	134.26	105.41	104.49	257.90	188.93
			GE 56	46.83	53.46	164.60	102.30	79.66	72.09	268.31	132.20
		FEMALE	LE 25	173.63	160.29	336.18	271.05	369.36	270.31	586.77	375.07
			26-55	65.16	46.66	142.99	75.67	136.79	77.65	283.01	118.72
			GE 56	57.07	48.96	270.20	126.27	140.55	95.58	535.73	198.48

Table D.4: Relative Standard Errors of Smoothed VMT Estimates (New Model)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.092955	0.068173	0.069647	0.071928	0.069185	0.073102	0.078919	0.093762
			26-55	0.095092	0.049770	0.054422	0.047134	0.069020	0.049806	0.056591	0.064106
			GE 56	0.149210	0.091577	0.147314	0.109381	0.157475	0.092607	0.155681	0.107706
		FEMALE	LE 25	0.080941	0.096926	0.079085	0.098308	0.081919	0.085734	0.092393	0.079561
			26-55	0.108577	0.069170	0.070908	0.060774	0.086543	0.083478	0.064984	0.078680
			GE 56	0.163695	0.098150	0.119784	0.120350	0.172220	0.111644	0.121830	0.116140
	RUSH	MALE	LE 25	0.098120	0.080641	0.072483	0.087090	0.092099	0.067959	0.091666	0.088054
			26-55	0.099165	0.059835	0.056091	0.060448	0.098100	0.075105	0.080713	0.080609
			GE 56	0.158887	0.090785	0.163968	0.116621	0.162144	0.092247	0.171417	0.118472
		FEMALE	LE 25	0.100603	0.105986	0.102562	0.109980	0.105116	0.092941	0.110878	0.082702
			26-55	0.106442	0.069684	0.074274	0.067692	0.093955	0.084092	0.070392	0.075155
			GE 56	0.138150	0.096476	0.111435	0.127969	0.125959	0.107505	0.097257	0.123381
	LATE	MALE	LE 25	0.123457	0.093145	0.101972	0.095013	0.107591	0.106150	0.115916	0.117808
			26-55	0.117677	0.075782	0.081672	0.071431	0.106778	0.092318	0.094638	0.093880
			GE 56	0.172313	0.134668	0.165649	0.151632	0.188448	0.125362	0.183639	0.136988
		FEMALE	LE 25	0.095222	0.114631	0.109872	0.127668	0.100212	0.106971	0.113287	0.097461
			26-55	0.124427	0.085260	0.092750	0.081313	0.111222	0.110351	0.083156	0.091682
			GE 56	0.186485	0.144439	0.161869	0.175814	0.181951	0.134910	0.146347	0.144217
MORE THAN ONE	OTHER	MALE	LE 25	0.098734	0.083138	0.096390	0.059743	0.108210	0.096152	0.084645	0.082706
			26-55	0.092057	0.049711	0.094097	0.081954	0.101326	0.067304	0.084782	0.077256
			GE 56	0.131413	0.109810	0.140203	0.107979	0.132673	0.111357	0.130593	0.100070
		FEMALE	LE 25	0.096876	0.123216	0.099094	0.105210	0.111208	0.122770	0.099610	0.085779
			26-55	0.087643	0.048547	0.088430	0.081410	0.089158	0.075382	0.098760	0.087298
			GE 56	0.227510	0.141970	0.233654	0.150634	0.229670	0.161908	0.240262	0.163013
	RUSH	MALE	LE 25	0.122722	0.119207	0.122331	0.084791	0.141923	0.112133	0.116532	0.088906
			26-55	0.091968	0.059677	0.124068	0.101611	0.107510	0.062066	0.120859	0.097738
			GE 56	0.150166	0.126207	0.165893	0.130663	0.144801	0.123955	0.153356	0.127613
		FEMALE	LE 25	0.097176	0.142271	0.097364	0.130823	0.096119	0.133338	0.071657	0.109911
			26-55	0.078966	0.064577	0.076013	0.099434	0.084374	0.082070	0.083970	0.111888
			GE 56	0.211164	0.129210	0.211503	0.132996	0.194614	0.142273	0.197655	0.138930
	LATE	MALE	LE 25	0.105407	0.131163	0.107721	0.089416	0.117688	0.125118	0.081661	0.095207
			26-55	0.095973	0.080217	0.109083	0.095767	0.120851	0.093721	0.104365	0.106521
			GE 56	0.164805	0.139932	0.188155	0.145471	0.168592	0.115769	0.179078	0.116444
		FEMALE	LE 25	0.140233	0.177590	0.143736	0.156717	0.180148	0.192089	0.145646	0.158829
			26-55	0.146389	0.113906	0.129055	0.125847	0.176642	0.155600	0.146448	0.161204
			GE 56	0.279015	0.189963	0.297030	0.217059	0.297344	0.208731	0.304599	0.220940

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SEASON: WINTER

OCCUPANTS	TIME	SEX	AGE	URBAN 5 YRS OR LESS LIGHT	URBAN 5 YRS OR LESS HEAVY	URBAN OVER 5 YRS LIGHT	URBAN OVER 5 YRS HEAVY	RURAL 5 YRS OR LESS LIGHT	RURAL 5 YRS OR LESS HEAVY	RURAL OVER 5 YRS LIGHT	RURAL OVER 5 YRS HEAVY
ONE	OTHER	MALE	LE 25	0.061531	0.069989	0.077269	0.066324	0.054590	0.072585	0.081113	0.085003
			26-55	0.071296	0.047145	0.088419	0.054788	0.064665	0.043042	0.087889	0.062522
			GE 56	0.154392	0.081140	0.152509	0.094952	0.173954	0.078001	0.161731	0.088327
		FEMALE	LE 25	0.086842	0.088799	0.100828	0.054445	0.115801	0.091315	0.135423	0.071956
			26-55	0.078480	0.071050	0.093252	0.052223	0.084118	0.099819	0.113634	0.098811
			GE 56	0.140931	0.085895	0.143240	0.123109	0.163536	0.110823	0.158633	0.135734
	RUSH	MALE	LE 25	0.074001	0.086174	0.074533	0.077121	0.075514	0.067811	0.080480	0.067605
			26-55	0.083031	0.058610	0.087179	0.055128	0.092617	0.067777	0.095805	0.066696
			GE 56	0.171863	0.085991	0.168671	0.094151	0.186658	0.082801	0.177252	0.090001
		FEMALE	LE 25	0.092962	0.093671	0.102790	0.060041	0.122971	0.088562	0.137233	0.063046
			26-55	0.072679	0.066918	0.086475	0.050955	0.087919	0.093050	0.112173	0.092274
			GE 56	0.122905	0.085698	0.136321	0.123991	0.134765	0.106014	0.145073	0.134580
	LATE	MALE	LE 25	0.099984	0.093993	0.102930	0.084984	0.099421	0.105205	0.128193	0.121900
			26-55	0.085210	0.072121	0.106559	0.086332	0.087757	0.085904	0.129318	0.115385
			GE 56	0.176723	0.122105	0.165810	0.126822	0.201561	0.111055	0.191509	0.120975
		FEMALE	LE 25	0.105954	0.118024	0.107251	0.081873	0.135152	0.108989	0.150774	0.087564
			26-55	0.084587	0.090416	0.091168	0.064406	0.102170	0.117897	0.125343	0.110692
			GE 56	0.175965	0.136482	0.175078	0.161911	0.189076	0.127900	0.187316	0.151545
MORE THAN ONE	OTHER	MALE	LE 25	0.102416	0.078849	0.083179	0.086543	0.148839	0.099581	0.100568	0.113179
			26-55	0.118305	0.070511	0.109348	0.092399	0.154447	0.087127	0.122533	0.097646
			GE 56	0.119359	0.103019	0.128156	0.119245	0.150591	0.111124	0.138882	0.121512
		FEMALE	LE 25	0.151290	0.125512	0.102303	0.099437	0.168988	0.119139	0.101056	0.083442
			26-55	0.120487	0.098075	0.104865	0.079626	0.130325	0.113884	0.114197	0.091433
			GE 56	0.177062	0.144284	0.211633	0.159017	0.180126	0.160724	0.216726	0.170644
	RUSH	MALE	LE 25	0.109495	0.099418	0.091280	0.083933	0.161715	0.105212	0.109458	0.105123
			26-55	0.112038	0.053547	0.125216	0.089546	0.150884	0.068939	0.139959	0.102500
			GE 56	0.141242	0.111660	0.154176	0.126477	0.164170	0.119041	0.163414	0.136726
		FEMALE	LE 25	0.132643	0.122385	0.086663	0.113177	0.145819	0.111403	0.066210	0.099082
			26-55	0.104580	0.082835	0.093845	0.080412	0.120686	0.102333	0.108655	0.104510
			GE 56	0.172832	0.121969	0.198782	0.135864	0.162059	0.140896	0.191118	0.148220
	LATE	MALE	LE 25	0.129538	0.139408	0.081754	0.079983	0.162678	0.136381	0.092102	0.107590
			26-55	0.131076	0.099940	0.110772	0.090676	0.166419	0.110585	0.131217	0.118256
			GE 56	0.168771	0.139900	0.177951	0.137600	0.187729	0.118456	0.185245	0.126081
		FEMALE	LE 25	0.172418	0.158770	0.135568	0.137600	0.212050	0.163907	0.146429	0.145628
			26-55	0.145935	0.105304	0.138093	0.108264	0.182043	0.142458	0.165400	0.152606
			GE 56	0.230334	0.182562	0.283146	0.214425	0.251658	0.195688	0.298102	0.221824

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Table D.5: Relative Standard Errors of Fatal Involvement Rates (Based on New Model)

SEASON: SUMMER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.139275	0.112249	0.109028	0.105273	0.112982	0.117131	0.126071	0.126904
			26-55	0.138907	0.083814	0.104103	0.078653	0.108376	0.082290	0.097176	0.091273
			GE 56	0.206914	0.149196	0.197228	0.156275	0.215629	0.139214	0.223273	0.157170
		FEMALE	LE 25	0.160172	0.158630	0.126513	0.147719	0.140724	0.135151	0.147066	0.130989
			26-55	0.164308	0.117632	0.137051	0.107806	0.129562	0.127483	0.115658	0.131523
			GE 56	0.242834	0.171018	0.206107	0.198149	0.231051	0.171383	0.179846	0.167977
	RUSH	MALE	LE 25	0.156827	0.135351	0.123991	0.134630	0.134964	0.101330	0.132784	0.128454
			26-55	0.169782	0.103626	0.115012	0.114538	0.168941	0.121009	0.126569	0.127079
			GE 56	0.258711	0.170067	0.228565	0.172226	0.240018	0.147514	0.251076	0.180906
		FEMALE	LE 25	0.188431	0.187488	0.170079	0.168911	0.185006	0.157472	0.174226	0.135942
			26-55	0.172279	0.121059	0.147766	0.118007	0.157556	0.138726	0.133041	0.144799
			GE 56	0.221505	0.164138	0.193627	0.209518	0.203172	0.177509	0.173281	0.204461
	LATE	MALE	LE 25	0.165296	0.130306	0.132879	0.128344	0.145003	0.144079	0.145918	0.141510
			26-55	0.163914	0.098801	0.126624	0.106731	0.151306	0.124332	0.126388	0.117392
			GE 56	0.259408	0.212125	0.243730	0.219730	0.282647	0.201238	0.272308	0.214640
		FEMALE	LE 25	0.161559	0.177766	0.170582	0.189000	0.160653	0.172915	0.185651	0.161718
			26-55	0.173214	0.134968	0.137116	0.125255	0.164192	0.161152	0.143584	0.155203
			GE 56	0.337213	0.272833	0.292686	0.284429	0.321190	0.252471	0.265085	0.256016
MORE THAN ONE	OTHER	MALE	LE 25	0.148243	0.129236	0.129375	0.098493	0.145563	0.127833	0.122762	0.108007
			26-55	0.141183	0.086551	0.138745	0.120960	0.138827	0.096654	0.122738	0.103408
			GE 56	0.205541	0.172016	0.201505	0.164347	0.198137	0.151761	0.196165	0.148414
		FEMALE	LE 25	0.164624	0.175046	0.154132	0.161754	0.155700	0.173080	0.149175	0.140204
			26-55	0.144995	0.097345	0.155987	0.131306	0.129551	0.117555	0.145181	0.124800
			GE 56	0.330165	0.225508	0.329861	0.232759	0.315073	0.232794	0.323127	0.238376
	RUSH	MALE	LE 25	0.187412	0.167673	0.188278	0.135131	0.191776	0.155043	0.162202	0.127396
			26-55	0.158813	0.112234	0.183063	0.153425	0.168289	0.112216	0.173841	0.144970
			GE 56	0.262807	0.222106	0.255040	0.217074	0.239985	0.196598	0.250487	0.208358
		FEMALE	LE 25	0.187050	0.224122	0.184957	0.216870	0.171814	0.198025	0.138303	0.174838
			26-55	0.146477	0.139795	0.127515	0.153361	0.147747	0.156781	0.142723	0.193184
			GE 56	0.338520	0.236616	0.303221	0.205451	0.290978	0.228610	0.287041	0.221697
	LATE	MALE	LE 25	0.156608	0.172395	0.143468	0.128325	0.155529	0.154692	0.108715	0.117302
			26-55	0.146033	0.118199	0.147913	0.134291	0.166857	0.126757	0.135256	0.141781
			GE 56	0.269800	0.235500	0.266887	0.233346	0.275409	0.200672	0.260174	0.199358
		FEMALE	LE 25	0.212395	0.231945	0.194263	0.215462	0.229501	0.239997	0.191425	0.206346
			26-55	0.206828	0.178082	0.189105	0.175855	0.233666	0.217750	0.203018	0.220755
			GE 56	0.435305	0.340757	0.414574	0.339488	0.421563	0.329190	0.427308	0.355497

Table D.5: Relative Standard Errors of Fatal Involvement Rates (Based on New Model) (continued)

SEASON: WINTER

			LAND USE:	URBAN				RURAL			
			VEHICLE AGE:	5 YRS OR LESS		OVER 5 YRS		5 YRS OR LESS		OVER 5 YRS	
			VEHICLE WEIGHT:	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY
OCCUPANTS	TIME	SEX	AGE								
ONE	OTHER	MALE	LE 25	0.111010	0.111320	0.122266	0.097269	0.094892	0.109524	0.129566	0.123819
			26-55	0.113720	0.076521	0.140661	0.088095	0.101104	0.073361	0.123248	0.090324
			GE 56	0.226783	0.136765	0.202200	0.127775	0.235472	0.129412	0.222706	0.129784
		FEMALE	LE 25	0.156493	0.139479	0.144213	0.101300	0.169380	0.133516	0.181964	0.118891
			26-55	0.126128	0.117384	0.143645	0.089073	0.137808	0.155132	0.164754	0.158146
			GE 56	0.216493	0.163002	0.221013	0.194010	0.218261	0.166881	0.230190	0.191292
	RUSH	MALE	LE 25	0.123974	0.142280	0.131616	0.138785	0.120666	0.113077	0.133786	0.126504
			26-55	0.154271	0.116743	0.146913	0.117957	0.157051	0.120544	0.134295	0.114588
			GE 56	0.253012	0.144165	0.234244	0.133678	0.258076	0.138132	0.248419	0.145774
		FEMALE	LE 25	0.175643	0.173545	0.171823	0.126098	0.201050	0.163647	0.192380	0.123729
			26-55	0.144087	0.127982	0.175449	0.117806	0.155463	0.155425	0.178705	0.162255
			GE 56	0.215907	0.168885	0.223083	0.209452	0.218767	0.187362	0.218062	0.222515
	LATE	MALE	LE 25	0.142867	0.130447	0.136419	0.112059	0.141404	0.141624	0.170559	0.154383
			26-55	0.133347	0.097655	0.151701	0.122628	0.134807	0.120792	0.172676	0.147645
			GE 56	0.273734	0.204775	0.248238	0.200819	0.303092	0.198771	0.284263	0.205529
		FEMALE	LE 25	0.180677	0.172946	0.176565	0.138979	0.199475	0.159988	0.228780	0.148288
			26-55	0.137942	0.141322	0.145487	0.119270	0.158191	0.172563	0.188686	0.177229
			GE 56	0.328741	0.267662	0.314361	0.278340	0.325866	0.243105	0.315257	0.260585
MORE THAN ONE	OTHER	MALE	LE 25	0.150954	0.119066	0.130232	0.127385	0.194363	0.136805	0.141023	0.142220
			26-55	0.166324	0.107018	0.154085	0.130433	0.193982	0.124527	0.154456	0.125182
			GE 56	0.203317	0.152540	0.188613	0.161370	0.223163	0.154259	0.197626	0.158244
		FEMALE	LE 25	0.214021	0.178390	0.158409	0.158722	0.214541	0.174429	0.141890	0.135738
			26-55	0.169621	0.142437	0.174329	0.135263	0.180729	0.165072	0.174581	0.146754
			GE 56	0.286810	0.241372	0.310960	0.249455	0.264121	0.229505	0.295295	0.235541
	RUSH	MALE	LE 25	0.169913	0.157443	0.153328	0.138263	0.206257	0.154176	0.151897	0.148464
			26-55	0.160922	0.105491	0.166847	0.136952	0.201256	0.131382	0.180415	0.150159
			GE 56	0.250705	0.198817	0.245744	0.207524	0.253845	0.188498	0.242733	0.200164
		FEMALE	LE 25	0.201982	0.185673	0.154962	0.178528	0.202216	0.167882	0.109249	0.153275
			26-55	0.173410	0.155899	0.161429	0.142140	0.173510	0.168579	0.179232	0.189989
			GE 56	0.313422	0.243666	0.305284	0.227595	0.269930	0.239933	0.268704	0.226023
	LATE	MALE	LE 25	0.174257	0.178009	0.118471	0.112515	0.207747	0.173802	0.131243	0.137256
			26-55	0.173576	0.136329	0.148297	0.134847	0.213500	0.153454	0.171022	0.163352
			GE 56	0.275541	0.228974	0.252643	0.223512	0.302506	0.212495	0.268212	0.213455
		FEMALE	LE 25	0.253545	0.215189	0.191948	0.189647	0.272775	0.208854	0.200165	0.189918
			26-55	0.209071	0.171771	0.202369	0.163181	0.245995	0.211310	0.225482	0.214568
			GE 56	0.384895	0.331287	0.391786	0.328895	0.373162	0.316339	0.416448	0.346648

APPENDIX E

Balanced, Partially Balanced, and Random Repeated Replications

When estimating variances for data collected according to a complex sampling plan, the method of repeated replications is recommended and if posible <u>balanced</u> repeated replications should be used. Balanced repeated replications were introduced in Reference 4. In that paper McCarthy estimated the relative variance of the variance estimate (variance of the variance estimate divided by the square of its mean) as

$$\frac{2\,(L-1)}{kL} + \frac{B+1}{2L}$$

when repeated replications according to <u>random</u> patterns of "1"s and "2"s (i.e. random choices of half strata for each replication) are used.

Here L represents the number of strata, k the number of replications used and B is a certain kurtosis which is therefore positive and might be expected to be around 3 or somewhat larger.

When <u>partially balanced</u> repeated replications are used the formula becomes

$$2\,(L-k)/(kL) + (B+1)/(2L)$$

so long as k L. When k = L then "partially balanced" becomes "balanced" and so the formula for <u>balanced</u> repeated replications is

$$(B+1)/(2L).$$

This is the minimum relative variance obtainable using repeated replications. Since L = 253 in the present study and only k = 20 replications were to be produced either partially balanced or random repeated replications had to be used. The ratio of relative variances between random and partially balanced repeated replications is estimated by

$$(2\,(L-1)/kL + (B+1)/2L) - (2\,(L-k)/(kL) + (B+1)/(2L))$$

This is easily seen to be less than (L-1)/L-k).

Substituting 20 for k and 253 for L, we estimate that the advantage for using partially balanced over random repeated replications is less than a factor of 1.08. In other words, using random rather than balanced repeated replications is estimated to result in a variance estimate with a relative variance at most 8 percent larger than that resulting from using partially balanced repeated replications.

Because the advantage in accuracy of the variance estimate for using partially balanced repeated replications is so slight, it was decided to use random repeated replications which were somewhat simpler to produce.

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