Accid. Anal. & Prev. Vol. 23, No. 5, pp. 431–436, 1991
Printed in Great Britain.

0001-4575/91 $3.00 + .00

DETERMINANTS OF MOTOR VEHICLE DEATHS IN THE UNITED STATES: A CROSS-SECTIONAL ANALYSIS

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Abstract—This paper uses 1987 state-level data and least-squares regression to estimate a model of motor vehicle deaths in the United States. The model includes several factors accounted for in previous cross-sectional studies of these fatalities. The estimates suggest that income, the ratio of urban to rural driving, expenditures on highway police and safety, motor vehicle inspection laws, and adult seat belt use laws with secondary enforcement provisions are inversely related to motor vehicle death rates. They also indicate that volume of driving, speed, speed variance, driving density, alcohol consumption, temperature, and a dummy variable for western states are directly related to the rates.

INTRODUCTION

Various studies have used cross-sectional data to analyze motor vehicle deaths in the United States. Examples include research conducted by Peltzman (1975), Koshal (1976), Crandall (1983), Lave (1985), Sommers (1985), Loeb (1985, 1987), Asch and Levy (1987), Zlatoper (1987), and Fowles and Loeb (1989). The cited studies utilized state-level data and typically employed least-squares regression as the estimation technique.

This paper also uses state-level data for the United States and regression analysis to estimate a model that explains motor vehicle fatalities. The model includes several potential determinants of these fatalities that were accounted for in the aforementioned studies. It also accounts for the influence of seat belt laws passed by several states during the 1980s. Data for 1987 are used to estimate the model.

The format of this paper is as follows: Section 1 specifies a general model of motor vehicle deaths. The data used in this study are described in the second section. Section 3 presents the estimation results. Section 4 provides a summary.

1. MODEL

The general form of the model for motor vehicle death rates that is estimated later in this paper is:

$$\begin{aligned} \text{DEATHRT} = f(&\text{INCOME, VOLUME, SPEED, SPEEDVAR,} \\ &\text{URBRUR, DENSITY, ALCOHOL, YOUTH,} \\ &\text{TEMP, POLICE, INSPECT, WEST,} \\ &\text{PRISBLAW, SECSBLAW, u)} \end{aligned} \tag{1}$$

where

DEATHRT = motor vehicle death rate;
INCOME = consumer income;
VOLUME = volume of driving;
SPEED = driving speed;
SPEEDVAR = variability of driving speed;

URBRUR = urban-rural driving mix;
DENSITY = driving density;
ALCOHOL = alcoholic intoxication while driving;
YOUTH = young drivers;
TEMP = temperature;
POLICE = expenditures on highway police and safety;
INSPECT = motor vehicle inspection laws;
WEST = dummy variable for western states;
PRISBLAW = primary seat belt laws;
SECSBLAW = secondary seat belt laws; and
u = random factors.

The independent variables accounted for in the model are necessarily selective and may exclude important influences. However, the indicated variables are a representative collection of factors accounted for in previous cross-sectional analyses of motor vehicle fatalities. The expected effect on DEATHRT of a change in each independent factor, other things being equal, is discussed below.

According to Peltzman (1975), a rise in real income would increase the demand for both safety and a consumption activity that he called "driving intensity" (e.g. speed and thrills). On the basis of this reasoning, income has an ambiguous effect a priori on death rates. However, several cross-sectional regression analyses of motor vehicle deaths [e.g. Peltzman (1975), Crandall (1983), Loeb (1985, 1987), Asch and Levy (1987), Zlatoper (1987), and Fowles and Loeb (1989)] found that these deaths are inversely related to income. Apparently, the demand for safety dominates in the income effect.

A greater volume of driving is expected to cause higher motor vehicle death rates due to increased exposure to dangerous driving situations. Because it is likely to increase the probability of accidents and, hence, deaths, speed is expected to have a direct effect on motor vehicle fatality rates. Results in many cross-sectional studies [e.g. Peltzman (1975), Crandall (1983), Loeb (1987), and Zlatoper (1987)] are consistent with the expectations pertaining to the impacts of volume and speed. Findings reported by Lave (1985) and Fowles and Loeb (1989) conform with the expectation of a direct relationship between variation in driving speed and traffic fatalities.

According to the National Safety Council (1989), fewer highway deaths occur in urban locations than in rural locations. This suggests that there is a lower probability of death given an accident in an urban setting. However, for a given level of exposure, the likelihood of an accident should be greater in an urban location. Therefore, the net effect of driving mix on fatality rates is uncertain a priori. However, results reported by Peltzman (1975) and Zlatoper (1987) indicate that the ratio of urban to rural vehicle-miles is inversely related to motor vehicle death rates.

As pointed out by Peltzman (1975), driving density has a complicated impact on highway death rates. All things being equal, greater density should increase the likelihood of accident and, hence, death. However, increased density may lead to a reduction in deaths by discouraging certain types of risky driving behavior (e.g. fast driving). On balance, the expected effect of driving density on motor vehicle death rates is unknown a priori. Loeb (1985, 1987) and Fowles and Loeb (1989) found overall density measures to be inversely related to motor vehicle deaths, while Peltzman (1975) and Zlatoper (1987) reported that urban and rural density measures had direct and inverse effects, respectively, on these deaths.

In concert with conventional wisdom on the relationship between drinking and driving, the level of alcoholic intoxication among drivers is expected to have a direct effect on highway fatality rates. Several previous cross-sectional studies [e.g. Peltzman (1975), Crandall (1983), Loeb (1985, 1987), Sommers (1985), Asch and Levy (1987), Zlatoper (1987), and Fowles and Loeb (1989)] presented evidence consistent with this expectation. Assuming that younger drivers take more risks than older drivers, it is anticipated that the proportion of young drivers is directly related to motor vehicle death rates. Results reported by Peltzman (1975), Crandall (1983), and Asch and Levy (1987) suggest that such a relationship exists.

Higher temperatures may adversely affect the comfort and, hence, the performance of drivers. Therefore, temperature is expected to be directly related to highway death rates. Findings in studies by Koshal (1976) and Zlatoper (1987) are in agreement with this expectation. Consistent with results reported by Zlatoper (1987), an increase in traffic supervision is expected to discourage risky driving and thereby reduce motor vehicle deaths.

It is expected that inspection programs enhance the safety of motor vehicles and thereby lead to fewer traffic deaths. Loeb (1985, 1987) and Fowles and Loeb (1989) cited results that conform with this expectation. Fowles and Loeb (1989) also noted that a dummy variable for western states should be directly related to motor vehicle fatalities. One reason for this anticipated relationship is the existence in some of these states of extended stretches of level, straight highways with low traffic volumes. Motorists are likely to be tempted to drive at higher speeds on such highways.

Since 1984, several states have put into effect adult seat belt use laws. The laws have either primary or secondary enforcement provisions. Under the primary enforcement policies, an officer can stop and charge a motorist for the sole reason of not wearing a seat belt. According to the secondary provisions, an officer can charge a motorist for not using a safety belt only after stopping the motorist for another traffic offense. Assuming that they lead to higher seat belt usage rates, both types of laws are expected to contribute to lower motor vehicle death rates. Time-series findings reported by Campbell and Campbell (1988) conform with this expectation.

2. DATA

Cross-sectional data for 1987 were used to estimate eqn 1. The data correspond to 47 of the contiguous states in the United States.* DEATHRT was measured by motor vehicle deaths per 100,000 population. *Highway Statistics 1987* (U.S. Federal Highway Administration 1987) was the source for the traffic death counts, while the population figures were taken from the *Statistical Abstract* (U.S. Bureau of the Census 1989).

INCOME was approximated by per capita disposable income (in dollars) as reported in the *Statistical Abstract* (U.S. Bureau of the Census 1989). VOLUME was represented by per capita vehicle-miles. Figures on vehicle-miles were taken from *Highway Statistics 1987* (U.S. Federal Highway Administration 1987), while the *Statistical Abstract* (U.S. Bureau of the Census 1989) was the source for the population values.

SPEED was measured by the average speed (in miles per hour) on urban interstate highways with a 55 mph speed limit. To create the proxy used for SPEEDVAR, this average speed was subtracted from the 85th percentile speed on the same highways. All of the speed data were taken from *Highway Statistics 1987* (U.S. Federal Highway Administration 1987).

URBRUR was approximated by the ratio of urban vehicle-miles to rural vehicle-miles. DENSITY was measured by the ratio of total vehicle miles (in millions) to highway miles. *Highway Statistics 1987* (U.S. Federal Highway Administration 1987) was the source for the vehicle-mile and highway-mile figures.

ALCOHOL was approximated by apparent per capita ethanol consumption (in gallons) for beer, wine, and spirits, as reported by Brooks and others (1989). YOUTH was measured by the percentage of the population that is 18 to 24 years old. Population figures from the *Statistical Abstract* (U.S. Bureau of the Census 1989) were used to compute this measure.

*West Virginia was omitted from the analysis due to missing data.

Table 1. Summary statistics on variables

Variable	Mean	Standard deviation
DEATHRT	20.607	5.642
INCOME	12411.437	2014.471
VOLUME	8290.266	1046.178
SPEED	58.040	1.921
SPEEDVAR	6.809	1.609
URBRUR	1.343	1.144
DENSITY	0.538	0.389
ALCOHOL	2.520	0.622
YOUTH	11.194	0.481
TEMP	54.354	7.488
POLICE	24.408	10.856
INSPECT	0.438	0.501
WEST	0.229	0.425
PRISBLAW	1.833	4.284
SECSBLAW	4.167	5.490

TEMP was approximated by the annual average normal daily mean temperature (in Fahrenheit degrees) for a selected city within each state as reported in the *Statistical Abstract* (U.S. Bureau of the Census 1989). POLICE was represented by per capita total expenditures (in dollars) by all units of government on highway law enforcement and safety.* *Highway Statistics 1988* (U.S. Federal Highway Administration 1988) was the source for the expenditure information, while the population figures were taken from the *Statistical Abstract* (U.S. Bureau of the Census 1989).

INSPECT was a dummy variable equal to one for all states that required an annual motor vehicle inspection and equal to zero, otherwise. The American Automobile Association (1987) was the source for this information. WEST was a dummy variable equal to one for all states in the Western U.S. Census Region and equal to zero, otherwise. The *Statistical Abstract* (U.S. Bureau of the Census 1989) indicated which states are in this census region.

In 1987, eight of the 47 states in the sample had primary adult seat belt laws, while another 20 states had secondary adult seat belt statutes. One of the primary laws and six of the secondary laws became effective at times after January 1, 1987. In order to account for the fact that enforcement periods varied across states, PRISBLAW was approximated by the number of months during 1987 that a primary law was in effect, and SECSBLAW was represented by the number of months during 1987 that a secondary law was in effect. These variables were constructed by using information on state seat belt laws reported by Williams and Lund (1988). Table 1 reports means and standard deviations for the variables used in the study.

3. ESTIMATION RESULTS

Using the data described in the previous section, a linear form of the model given in eqn 1 was estimated by least-squares regression. A test for heteroscedasticity proposed by White (1980) was performed on the estimated model. The null hypothesis that all the error terms have the same variance was rejected at a significance level of 1%. As a result, the regression estimates were adjusted for heteroscedasticity. Table 2 reports the adjusted estimates.

As expected, the signs of the estimated coefficients of INCOME, URBRUR, POLICE, INSPECT, and SECSBLAW are negative; and the signs of the estimated coefficients of VOLUME, SPEED, SPEEDVAR, ALCOHOL, TEMP, and WEST are positive. Each of these estimated coefficients, except for those associated with INSPECT and SPEEDVAR, is significant at a level of 5% or less. DENSITY has a positive estimated coefficient that is significant at a level of 5%. This result contrasts with the

*According to *Highway Statistics 1988* (U.S. Federal Highway Administration 1988), the expenditures are for "activities of the federal highway safety program, state highway patrols, safety education and promotion, driver training programs, and enforcement of vehicle size, weight, and emissions limitations."

Table 2. Cross-sectional regression estimates of motor vehicle death rates in the United States for 1987.* (Dependent variable: DEATHRT)

Independent variable	Expected sign	Estimated coefficient	t-statistic
Intercept		2.073	0.121
INCOME	−	−0.002	−4.700
VOLUME	+	0.001	2.737
SPEED	+	0.363	2.472
SPEEDVAR	+	0.287	1.057
URBRUR	−	−1.807	−3.648
DENSITY	?	7.242	3.355
ALCOHOL	+	2.646	3.270
YOUTH	+	−0.735	−0.838
TEMP	+	0.203	3.543
POLICE	−	−0.109	−3.239
INSPECT	−	−0.950	−1.167
WEST	+	3.053	3.194
PRISBLAW	−	0.010	0.095
SECSBLAW	−	−0.165	−1.970
R^2		0.839	
$\bar{R}^2$		0.768	
N		47	

*Note: The estimates have been adjusted for heteroscedasticity.

significant inverse relationship between density and motor vehicle deaths reported by Fowles and Loeb (1989).

The estimated coefficients for YOUTH and PRISBLAW have unexpected signs but are highly insignificant. It is noteworthy that other studies (e.g. Loeb 1987; Zlatoper 1987; Fowles and Loeb 1989) have reported an insignificant relationship between the percentage of young drivers and motor vehicle deaths. The results pertaining to PRISBLAW are not consistent with findings reported by Campbell and Campbell (1988). These researchers found that motor vehicle fatalities in a set of U.S. seat belt law jurisdictions were 6.6% lower than the total forecast from past trends. The insignificance of PRISBLAW in this study may be due to the fact that the measure does not represent some important aspects of the various primary seat belt laws. For instance, the measure does not account for how strongly states enforced their laws during 1987.

There is evidence of a multicollinearity problem in this study. The condition index for the estimated regression equals 243. According to Gujarati (1988), a condition index in excess of 30 is indicative of severe multicollinearity. Some of the insignificant results noted above may be due, at least partly, to this problem.

Because of its potential impact on motor vehicle fatalities, the Surface Transportation and Uniform Relocation Assistance Act of 1987 warrants mention. This act permitted states to increase the speed limit to 65 mph on interstate highways located in areas with populations of less than 50,000. A dummy variable equal to one for states that raised the speed limit was added in a reestimation of the model. Its estimated coefficient had an unexpected negative sign but was highly insignificant.

4. SUMMARY

Using 1987 state-level data for the United States, this paper estimated a regression model of motor vehicle deaths. The determinants accounted for in the model were representative of factors included in previous cross-sectional studies. In general, the regression results of this study were consistent with findings reported elsewhere. They suggested that the following factors are inversely related to motor vehicle death rates: income, the ratio of urban to rural driving, expenditures on highway police and safety, vehicle inspection, and adult seat belt use laws with secondary enforcement policies. The results also indicated that volume of driving, speed, speed variance, driving density, alcohol consumption, temperature, and a dummy variable for western states are directly related to motor vehicle fatality rates.

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