Unemployment and Highway Fatalities

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Abstract. We considered unemployment, an often overlooked covariate of highway fatalities, hypothesizing that (1) as unemployment rises, aggregate driving decreases, especially among the unemployed, and as driving decreases, fatalities should decrease; (2) unemployment may influence drinking—some among the unemployed may drink less due to lower incomes, while others may drink more due to stress so the net effect would be ambiguous; and (3) unemployment may increase aggregate levels of stress and unhappiness, which can result in poor concentration on driving and thus, in turn, should result in more accidents and deaths. We used data from fifty states and the District of Columbia from 1976–1980, representing 255 observations. (No prior study has as many observations or controls for as many covariates.) Using econometric models of the data, we present evidence for two of the three hypothesized effects of unemployment. We conclude that, if the number of miles driven is held constant, worsening unemployment leads to higher fatality rates, most likely due to stress effects. But because more unemployment means less driving, increases in unemployment, on balance, are associated with decreases in fatalities.

In recent years, road and highway fatalities have claimed between 43,000 and 54,000 lives annually. Since a disproportionate number of fatalities occur among the young, the sum of the years of potential life lost is staggering. Foege et al. (1985) show that the years of potential life lost due to highway crashes are nearly as many as number lost due to heart disease. Yet the research attention devoted to highway deaths has been paltry compared to that devoted to heart disease. This lack of attention, in part, is the result of a bias against social science research in favor of natural science research since highway accidents, like most accidents, are frequently viewed as resulting from human error. It is also the result, in part, of the relatively few social science studies which have attempted to show any relationship between traditional social science variables and health outcomes. Our study represents another attempt to demonstrate how

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social science can be useful in explaining a health variable of significant proportions—highway fatalities. We directed our attention toward unemployment, an underresearched covariate. Our literature search found only two highly aggregated studies of highway fatalities that considered unemployment as a possible predictor (Wagenaar 1984; Partyka 1984). Moreover, the words "unemployment" or "job loss" do not appear in any of the indexes to three popular books on injuries, by Foege et al. (1985), Baker et al. (1984), and Robertson (1983). Unemployment and general ill-health associations, on the other hand, have been extensively studied.

Review of literature on unemployment and psychological and physiological health

Harvey Brenner (1971, 1973, 1976, 1979, 1980), Bunn (1979), Catalano and Dooley (1983), Cobb and Kasl (1977), Eyer (1977), Moser et al. (1984, 1986), and Leigh (1987) have discovered statistical associations between unemployment and measures of poor psychological and physiological health. Advocates of the unemployment and ill-health hypothesis hold that unemployment, particularly extended unemployment, can result in stress, unhappiness, ill health, disability, and early death. Recent evidence in the psychological literature on the association between unemployment and the strength of the immune system appears to support this view (Arnetz et al. 1987). Lengthy unemployment may be especially serious since it can result in loss of health insurance and illness may go untreated (Podgursky and Swain 1987).

Charlton et al. (1987), Gravelle et al. (1981), Kasl (1979), and Joyce (1990), however, challenge the stress hypothesis. The critics maintain that (1) the statistical models are poorly conceived, and (2) while unemployment may cause some psychological hardship, it is unlikely to result in serious physiological problems. The statistical problems arise from the lag structure of the models. Is it the person's current unemployment that can lead to immediate death, or is it extended bouts of unemployment in past years that have a cumulative effect? The lag structure is important if the cause of death is a chronic disease, such as heart disease or cancer, since chronic diseases require years of gestation. Charlton et al. (1987) and Gravelle et al. (1981) reestimate the statistical models with varying lag structures and demonstrate the frailty of the results in Brenner's and other advocates' studies. Skeptics also point out that while much of the public believes that stress can lead to physiological illness, the hypothesis is not widely accepted in the scientific medical community.

An investigation of unemployment and vehicle accidents in total miles or per mile driven might avoid the two complaints lodged by the critics. First, accidents are acute, not chronic. If unemployment and accidents were related, it would not be necessary to introduce a lag structure into the model. Second, even the critics grant that unemployment can lead to psychological difficulties.

If one of those difficulties is lack of concentration or increased drinking, even they may allow that a relation could be found between unemployment and accidents in total miles or per mile driven.

An investigation of the relation between unemployment and highway accidents may introduce several new problems, however. First, as unemployment worsens, unemployed people may drive less. Employed people, too, fearing unemployment, may drive less and save the money they would otherwise spend on gasoline. This effect on driving may be especially noticeable among young males, where unemployment is volatile. Second, unemployment results in lower incomes, which, in turn, could result in less alcohol consumption and, thus, fewer crashes (assuming a causal connection between alcohol use and crashes).

The hypotheses that link increased stress and drinking to unemployment predict a positive correlation between unemployment and fatalities, whereas hypotheses linking decreased driving and drinking to unemployment predict a negative one.

Review of literature on highway fatalities

The literature on highway fatalities is split into two categories: studies on technological improvements in the safety design of automobiles and the human response to those designs, and studies on the human capabilities of driving in general. Airbags, seatbelts, shoulderbelts, soft dashboards, collapsible steering wheels, car weight, and so on, have received attention in the engineering literature. A good review of these studies is provided in Robertson (1983) and Crandall et al. (1986).

Peltzman (1975) sharply criticized the engineering studies for not accounting for peoples' responses to the new safety innovations. He argued that people have a given desire for risk and that if, for example, they are forced to buy safer cars, they will drive more recklessly. Peltzman's study has since served as a lightning rod. His conclusions have been challenged by many researchers who do not find evidence that safety innovations lead to more careless driving. Many of the studies surrounding the Peltzman debate are reviewed in Crandall et al. (1975).

Regardless of the viability of Peltzman's controversial assertions, there is no doubt that the debate his study generated served to remind researchers that the behavioral element cannot be ignored in analyzing annual fluctuations in highway fatalities. Since Peltzman's study, social scientists, and economists in particular, have ventured beyond the narrow question of the human response to engineering safety innovations into questions involving the general sociological, demographic, and economic correlates of highway fatalities. Since this study considers an underresearched economic covariate, unemployment, the recent studies on the general covariates and the two on unemployment are reviewed below.

The Appendix presents a partial review of fifteen of the more notable studies from recent years. The first thirteen studies considered general covariates of fatalities. The last two studies focused on unemployment.

The authors of the first thirteen studies have each had their favorite variables. Crandall et al. (1986) Zlatoper (1987), and Robertson (1983) were concerned primarily with testing Peltzman's hypothesis. Safety features were indirectly measured in these studies, based on the percentage of new cars among those registered. Crandall et al. and Robertson found that the engineering safety features decreased fatalities, while Zlatoper found that they were positively associated with fatalities. McKenzie and Warner (1987) wanted to estimate the relationship between increased airline use since the 1978 deregulation of airlines and the possible reduction of car and truck use, and the resulting reduction in highway fatalities. Wilkinson (1987) was concerned with state laws governing drunk driving. Four studies, those by Fuchs and Leveson (1967), Crain (1980), Loeb (1985), and Loeb and Gilad (1984) were concerned with whether state-mandated vehicle inspection laws were associated with reduced fatalities. Three others, by Levy and Asch (1989), Lave (1985), and Fowles and Loeb (1989) concerned the variance of speed as a predictor of fatalities.

Wagenaar (1984) and Partyka (1984) were the only studies to consider unemployment. Both studies used time series data. Partyka used annual U.S. data, while Wagenaar used monthly data from Michigan only. Partyka entered controls for the number of employed and number of people not in the labor force. Wagenaar controlled for vehicle miles traveled. Neither unemployment study controlled for the many covariates considered in other studies, however, such as alcohol consumption, percentage of young drivers, average and standard deviation of speed, and percentage of new cars. In addition, the two unemployment studies did not attempt to account for variations in vehicle inspection laws, drinking-age laws, and motorcycle helmet laws, to the extent that these laws changed in Michigan (Wagenaar) or any state (Partyka) over time. In brief, the list of covariates held constant in these two unemployment studies is too short. We cannot determine whether a correlation between unemployment and fatalities merely reflects the influence of some third variable, such as alcohol consumption. Nevertheless, both studies found unemployment and highway fatalities to be inversely related.

None of the studies listed in the Appendix had all of the independent variables from any prior study. Nevertheless, several statistically significant variables appeared in most of the first thirteen. Per capita alcohol consumption appeared statistically significant in eight studies. Miles driven and/or gasoline consumption per capita appeared statistically significant in eleven studies. As Zlatoper (1987) points out, miles driven and gas use will be very strongly associated for obvious reasons. A measure of young drivers or young male drivers was included in ten studies and was statistically significant in seven. Some measure of rural and urban miles traveled or population density appeared in eight studies and was statistically significant in five. Robertson's (1983) many studies suggest that the percentage of new cars, changes in motorcycle helmet laws, and laws governing drinking age cannot be ignored. Three studies considered vehicle inspection laws. All three found that these laws were significantly associated with fewer fatalities. This favored set of variables—alcohol use, percentage of young or male drivers, measures of urban and rural miles driven, helmet laws, minimum drinking-age laws, percentage of new cars, and a variable reflecting vehicle inspection laws—appeared to be the set of variables necessary in any analysis attempting to explain highway fatalities. None of the other independent variables, mentioned in the Appendix are listed as frequently as these, or given as much attention in the studies.

Materials and methods

Most of the variables analyzed here are drawn from the data collected by Wilkinson (1987). Variables collected by the author include data on unemployment, vehicle inspection laws, helmet laws, and the percentage of new car registrations in the fifty states and the District of Columbia. Wilkinson's data are used for two reasons. First, his data contain all those variables in the favored set listed above, with the addition of the vehicle inspection variable, helmet laws, and the percentage of new car registrations. Second, his data contain many more observations than any other study. Every other study listed in the Appendix is either a cross-section or time-series data set. Wilkinson's data are both. Wilkinson pooled data from the fifty states and the District of Columbia together for the years 1976 through 1980. He thus has 255 observations on most variables. The variables for which he did not have all the observations are excluded from my study.

Table 1 presents the descriptions of variables used in the analysis. The means and standard deviations do not exactly match those appearing in the Wilkinson study since this study uses all 255 observations, not just the 221 observations Wilkinson analyzed.

All of the variables, except vehicle inspection laws, are self-explanatory. The vehicle inspection variable was created by gleaning data from the American Automobile Association's *Digest of Motor Laws* (1980). The vehicle inspection variable assumed only four values: 0, 1, 1.5, and 2. If, say, Arkansas had a vehicle inspection law in 1976 which required an annual inspection for reasons other than smog control (as, in fact, Arkansas did), then Arkansas in 1976 would receive a 1 for the vehicle inspection variable. New Hampshire received a 2 in every year because New Hampshire's law required an inspection every six months. California received a 0 in every year because California did not have an inspection requirement. Rhode Island and Utah received a 1.5 since the *Digest of Motor Laws* indicated that many vehicles required two annual checks, while others required only one. A distinct advantage of these data over

Table 1. Variable Statistics and Descriptions

Variable	Type	Source[a]	Mean	Standard Deviation	Description
Fatalities	Continuous	1	964	950	Fatalities
Pop > 15	Continuous	3	3,290	3,498	Number of people over age 15 in thousands
Urban miles	Continuous	4	1.457	0.347	Number of miles traveled on urban roads measured in 1,000 miles per person over age 15
Rural miles	Continuous	4	1.439	0.961	Number of miles traveled on rural roads measured in 1,000 miles per person over age 15
% young males	Continuous	4	0.119	0.012	Percentage of licensed drivers who are males younger than age 24
Average speed	Continuous	4	54.9	2.29	Average vehicle speed weighted by numbers of miles traveled
St. dev. speed	Continuous	4	1.609	0.107	Average standard deviation of vehicle's speed weighted by vehicle miles traveled
Gas consumpt	Continuous	4	2,111	2,124	Gallons of gas used per person over age 15
Alcohol consumpt	Continuous	5,6	1.050	0.275	Gallons of ethanol consumed per person over age 15
% unemployment	Continuous	3	6.430	1.861	Statewide level of unemployment

Inspect	Discrete 0, 1, 1.5, 2	7	0.678	0.661	Number of annual inspections
Drinking age under 21	Binary	5	0.216	0.418	Binary: equals 1 if state has minimum legal drinking age less than 21, including for 3.2% beer
% new cars	Continuous	2	9.6	5.8	New car registrations as a percentage of total state registrations
Helmet law	Binary	8	0.71	0.362	Binary: equals 1 if helmet law covering all motorcyclists was in effect for more than 6 months

a. *Sources:* 1. U.S. Department of Transportation (1982).
2. *American Automobile Association* (1981).
3. U.S. Department of Commerce (1976–81).
4. U.S. Department of Transportation (1982).
5. Distilled Spirits Council (1982).
6. U.S. Brewers Association (1981).
7. American Automobile Association (1980).
8. Sass and Leigh (1991).

all other in the literature is their number–they contain 255 observations. The largest samples in the literature contain only 50 or 51. A further advantage is that, over this time period, a handful of states changed their laws. Idaho, Kentucky, and New Mexico went from requiring one inspection to not requiring one. Virginia dropped from two inspections to one.

Following the precedent of statistical analysis used in the thirteen studies listed in the Appendix, we used multiple regression analysis, correcting for differing error variances across time and states, to ferret out the separate associations of alcohol use, gas consumption, unemployment, vehicle inspection, and so on, with fatalities per capita. Multiple regressions were corrected for random effects and run using the Regression Analysis of Time Series (RATS) statistical program (1984). Except for the variables of unemployment, drinking age, vehicle inspection, and the percentage of young male drivers, each variable was entered as a natural logarithm so that the estimated coefficient could be interpreted as an elasticity. An elasticity represents the percentage change of a dependent variable associated with a percentage change in an independent variable (Leigh 1988).

Three effects of unemployment on fatalities can be imagined. (1) As unemployment increases, total driving may decrease. The unemployed may feel financially constrained while the employed may fear unemployment, so that both seek to limit their spending on gasoline for unnecessary travel. The reduction in driving may be particularly great among male youth, who are liable to be unemployed. Unemployment of males less than twenty-five years old can sometimes be three times the rate of unemployment among males over twenty-five (Kaufman 1989). Since a disproportionate number of deaths occur among young drivers, if the young curtail their driving—for any reason—it is likely that total highway deaths should fall. (2) Unemployment may be related to excessive drinking. To relieve the boredom of unemployment, the unemployed may drink and drive more frequently than if they were employed. On the other hand, unemployment, which reduces income, may lead to less drinking. Berger and Leigh (1988), for example, find a strong positive association between decreased alcohol consumption and decreased earnings among full-time workers. (3) Unemployment may cause stress and unhappiness which can result in difficulty in concentrating while driving and, hence, more fatal accidents.

It is unlikely that the number of miles driven would have a direct effect on unemployment; thus, causality can be assumed to run in only one direction.

These three hypotheses can be systematically addressed by selective inclusion and exclusion of independent variables in the regression equations. For example, to test whether the conflicting effects in (1) and (2) above are greater or less than the effects in (3), regressions are estimated which alternately include and exclude miles driven, percentage of young male drivers, and alcohol consumption, while always including unemployment, the inspection law variable, average speed, standard deviation of speed, percentage of new car registrations, the helmet law variable, and a minimum drinking-age law variable. For example, when miles driven, percentage of young male drivers, alcohol consumption, and other variables are included in the equation, the first two effects are accounted for so that the hypothesis that unemployment can lead to unsafe driving due to stress can be tested. When miles driven, alcohol consumption, and percentage of young male drivers are excluded from the equation, but all others are entered, the *net* association of all three hypothesized effects can be tested.

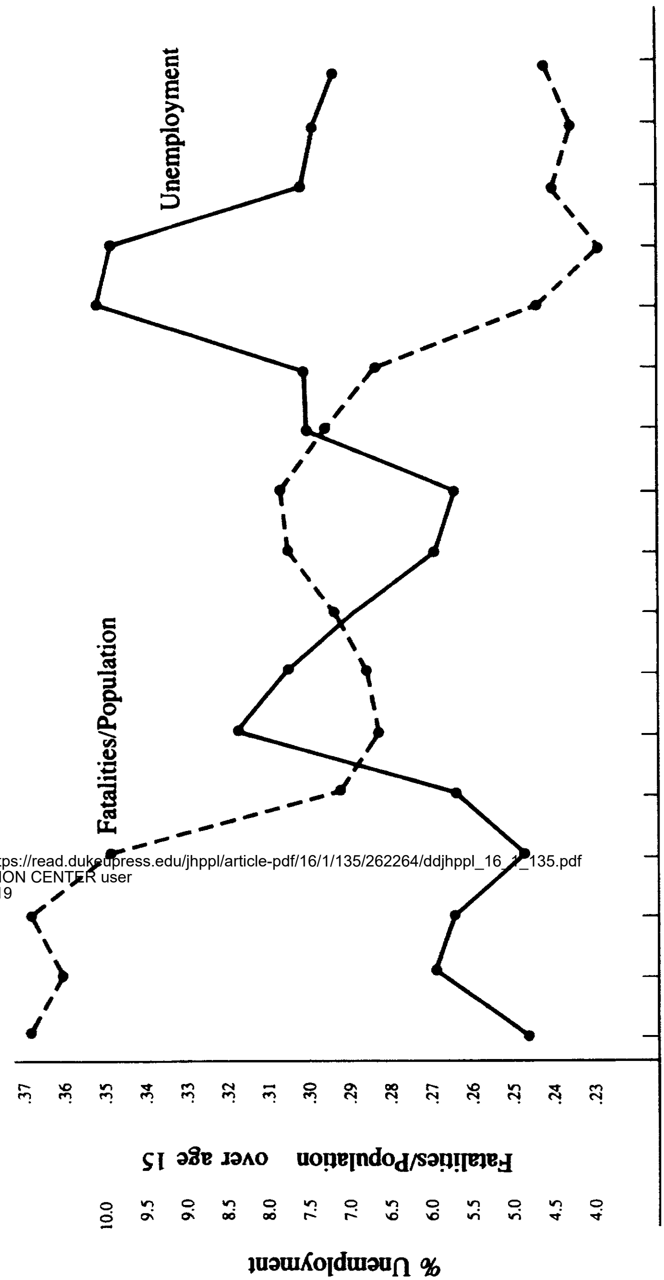
Alcohol consumption, percentage of young males, and miles driven are referred to as intervening variables, since unemployment is alleged to have an indirect effect on fatalities through its effects on these independent variables. Unemployment may have direct effects on fatalities: these would consist of any hypothesized influence it might have independent of alcohol consumption, percentage of young males, and number of miles driven. For example, unemployment could result directly in poor driving concentration.

Assuming that causality runs in one direction, that is, from unemployment to number of miles driven, or unemployment to the percentage of young male drivers, or unemployment to alcohol consumption, then each of the hypotheses can be tested with multiple regression techniques (Maddala 1988).

Results

The statistics in Figure 1 provide a simple picture of the aggregate relation between unemployment and highway fatalities per person over the age of fifteen. The pattern is striking. When national unemployment has been low, the fatality rate has been high, and vice versa. But the statistics in Figure 1 are very limited. The fatality rate dropped considerably as a result of the fifty-five-miles-per-hour speed limit introduced in 1974 and the international gasoline shortages in 1973 and 1979.

A more systematic look at the relation between unemployment and highway fatalities is provided by an analysis of the data available in Wilkinson (1987). Table 2 presents the results of estimating equations that explain the fatality rate. Table 2 does not include either a variable for the 1974 fifty-five-miles-per-hour speed limit nor a variable for the dramatic increases in gas prices in 1973 and 1979. The data begin in 1976, two years after the national fifty-five-miles-per-hour speed limit was established. Throughout the data period, from 1976 to 1980, the national speed limit remained at fifty-five. In these data, therefore, the fifty-five-miles-per-hour speed limit was not likely to explain state-to-state or year-to-year fluctuations in the fatality rate. As regards the second point, Leigh and Wilkinson (1988) explain that it is not necessary to account for the effects of the gas price if the effects of miles driven are accounted for. That is, an increase in the gas price can only have an indirect, not a direct, effect on the fatality rate. As gas prices rise, people consume less gasoline and drive



Year	% Unemployment	Fatalities/Population over age 15
1970	4.9	.3676
1971	5.9	.3604
1972	5.6	.3682
1973	4.9	.3535
1974	5.6	.2916
1975	8.5	.2828
1976	7.7	.2862
1977	7.0	.2975
1978	6.0	.3073
1979	5.8	.3082
1980	7.5	.2963
1981	7.6	.2819
1982	9.7	.2475
1983	9.6	.2273
1984	7.5	.2441
1985	7.2	.2386
1986	7.0	.2482

Figure 1. Highway Fatalities and Unemployment

Table 2. Regressions Explaining Log of Fatalities per Person over Age 15 within a Given State and Year, 1976 to 1980

Independent Variable	Estimated Coefficient (Absolute Value of t-Statistic)					
	1	2	3	4	5	6
Constant	− 0.826*	− 18.250*	− 10.865*	− 15.524*	− 5.717*	− 6.268*
	(10.317)	(9.624)	(9.077)	(9.604)	(3.767)	(8.846)
Unemployment rate	− 0.052*	− 0.029*	− 0.027*	− 0.012	0.022*	0.021*
	(4.326)	(2.359)	(2.296)	(1.298)	(2.674)	(2.596)
Ln (urban miles) driven per person over age 15)					− 0.020	0.126
					(0.321)	(2.749)
Ln (rural miles driven per person over age 15)					0.114*	0.482*
					(6.154)	(6.477)
Ln (alcohol consumption per person over age 15)			0.076			0.092*
			(0.729)			(1.985)
Percentage of young male drivers				16.801*		7.649*
				(12.113)		(6.882)

Table continues following page

Table 2. *Continued*

Independent Variable	Estimated Coefficient (Absolute Value of *t*-Statistic) 1	2	3	4	5	6
Inspection		− 0.078*	− 0.078*	− 0.056*	− 0.048*	− 0.039*
		(2.370)	(2.206)	(2.592)	(2.292)	(1.094)
Ln (average speed		4.269*	4.360*	2.295*	1.191*	1.205*
		(9.830)	(9.740)	(7.389)	(3.249)	(3.459)
Ln (standard deviation of speed)		1.177*	1.028*	0.989*	0.599*	0.598*
		(3.940)	(3.724)	(9.210)	(3.053)	(3.274)
Drinking age < 21		0.914*	0.898*	0.840*		0.716*
		(3.746)	(3.640)	(3.419)		(2.863)
Percentage of new cars		− 0.174*	− 0.159*	− 0.142*	− 0.186*	− 0.136*
		(3.982)	(3.862)	(3.700)	(3.429)	(2.165)
Helmet law		− 0.017*	− 0.016*	− 0.016*	− 0.013*	− 0.011*
		(2.853)	(2.650)	(2.582)	(2.900)	(2.268)
R^2	0.069	0.536	0.590	0.619	0.763	0.822
n	255	255	255	255	255	255

Note: Each regression was estimated allowing for random effects. Values in parentheses are *t*-statistics.
* Significant at the .05 level in the appropriate one- or two-tailed test.

less, other things being equal. The association between gas prices and fatalities should, therefore, be accounted for within the association between miles driven and fatality rates.

The results in the first column of numbers in Table 2 are analogous to those in Figure 1. The estimated coefficient is negative and strongly statistically significant with a t-statistic of 4.326. Equation 1 (column 1) represents a theoretical extreme which assumes, probably incorrectly, that all of the additional independent variables in Table 2—urban vehicle miles through the helmet law—are strongly influenced by the unemployment rate. Nevertheless, if this assumption is invoked, then a 1 percentage increase in the unemployment rate, from, say, 6 to 7 percent, would be associated with a roughly 5 percent reduction in the fatality rate. (The estimated coefficient, − 0.052, must be multiplied by 100, because unemployment rates were entered into the computer as .05, .06, .07, etc., for 5, 6, and 7 percent.)

Equation 2 (column 2) corresponds to a less extreme theoretical view. The equation assumes that the percentage of new cars, the inspection law, the average speed, the standard deviation of speed, the drinking-age law, and the helmet law are not influenced by the unemployment rate, but that alcohol consumption, percentage of young male drivers, and number of miles driven are influenced by the unemployment rate. Increased unemployment, for example, could lead to reduced consumption of gas and thus to reduced driving, especially among youth; and to reduced alcohol consumption due to lower incomes. Alternatively, more alcohol consumption due to stress could result in more crashes as unemployment worsened. In any case, column 2 presumes that vehicle miles, alcohol consumption, and percentage of young males are variables intervening between unemployment and fatalities. Again, the *negative* and statistically significant association between unemployment and the fatality rate is apparent.

Beginning with column 3, the intervening variables are taken into account as alcohol consumption, percentage of young male drivers, and number of miles driven are entered into the equations. Each of these three variables has been alleged to be influenced (if indirectly) by the unemployment rate, that is, they have been alleged to be intervening variables. As the results in column 3 suggest, when alcohol consumption is added to the equation, the estimate of the association between unemployment and the fatality rate appears not to be affected. The estimated coefficients on unemployment in columns 2 and 3 are almost identical. The results suggest that alcohol consumption is unrelated to unemployment, or that the effects are sufficiently conflicting to render the overall association nil. But this may not be the most reasonable final conclusion about alcohol consumption, given the results in column 6, as will be seen.

The addition of the percentage of young male drivers appears to matter. The estimated coefficient on unemployment, while still negative, drops by half and is no longer statistically significant in equation 4. The estimated coefficient on the percentage of young male drivers is strongly significant in explaining the fatality rate, however, with a *t*-statistic above 12.

Finally, the addition of the miles-driven variables drastically affects the estimated association. The estimated coefficients on the unemployment rate in columns 5 and 6 are *positive* and statistically significant at the .05 level. A t-statistic of 1.96 or higher is required for the two-tailed statistical significance with a sample size of 255. Estimated coefficients on the urban- and rural-miles-driven variables draw large t-statistics. Alcohol consumption now becomes positively and statistically significant in its association with fatalities.

To consider the inspection variable and the binary law variables for the drinking age, it is first necessary to interpret their estimated coefficients. Since the dependent variable is a logarithm, an estimated percentage effect can be calculated by $\exp(\beta - 1)$, where β is the estimated coefficient. If β is small, say, less than 0.12, as it is in Table 2, then $\exp(\beta - 1) \simeq \beta$ (Halvorsen and Palmquist 1980). The estimated coefficients can, therefore, be interpreted approximately as the percentage changes in the fatality rate associated with one more required inspection per year. The estimated effects of inspection in Table 2 thus range from 3.6 to 6.8 percent, which are smaller than the 14 to 26 percent effects in Loeb and Gilad (1984), or the 13 to 19 percent effects in Loeb (1985), or the 5 to 10 percent effects in Fuchs and Leveson (1967). It may be that one reason for the smaller estimates in Table 3 is this study's use of a sample which is five times the size of any of the prior studies. More precise estimates result when sample sizes increase. Laws which allow eighteen-, nineteen-, and twenty-year-olds to drink are associated with roughly 7 to 9 percent more fatalities than laws which allow only persons twenty one and over to drink. States with helmet laws have roughly 1 to 2 percent fewer total fatalities than states without helmet laws. The effect would undoubtedly be larger if the dependent variable had been motorcycle fatalities rather than total fatalities (Sass and Leigh forthcoming).

Discussion

Three unemployment results require explanation:

(a) The unadjusted univariate association between unemployment and fatalities (column 1), as well as the association adjusted for alcohol consumption and the other controls (columns 2 and 3), are negative and strongly statistically significant.
(b) The association becomes statistically insignificant, yet remains negative, once the percentage of young male drivers is accounted for.
(c) When miles driven are accounted for, the association becomes positive and statistically significant.

To explain (a) above, it should be recalled that two opposing views of the link between alcohol consumption and unemployment could be cited. On the one hand, as unemployment increases, it could be that alcohol consumption increases as the unemployed drown their sorrows. On the other hand, the unemployed may cut their consumption of alcohol, viewing alcohol as a luxury rather than a necessity. The results in Table 3 suggest that neither effect dominates. A simple correlation coefficient between alcohol consumption and unemployment was calculated to test the conclusion that the net effect was nil. The coefficient was 0.094, which is *not* statistically significant at the .05 level in a two-tailed test. It therefore appears credible to conclude that the two influences of unemployment on alcohol use cancel each other out. Apparently, once the intervening variable of alcohol use is accounted for, the association between unemployment and fatalities is negative: as unemployment worsens, highway fatalities drop.

The result in (b) was expected. Miles driven among young males may be strongly related to their employment status. If a young male becomes unemployed, the results in Table 2 suggest, he is likely to curtail his driving. As an additional test of this conclusion, a correlation coefficient was calculated between percentage of young male drivers and fatality rate. The coefficient was 0.142, which carries a *p*-value of .05, implying a statistically significant correlation.

The result in (c) resolves conflicting prior hypotheses. If the association between miles driven and the fatality rate can be controlled for, then any remaining association between unemployment and fatalities is due to either the young-male-driver hypothesis, the alcohol-use hypothesis, or the stress hypothesis. The results in column 5 reveal that the stress effect may be more powerful than the young-male-driver effect or the alcohol effect in explaining the association between unemployment and fatalities, holding miles driven constant.

Conclusions

The hypothesis that unemployment can lead to anxiety and poor driving, holding constant the amount of driving and percentage of young male drivers, is supported. This conclusion is consistent with the studies by Brenner (1971, 1973, 1976, 1979, 1980), Bunn (1990), Moser (1984, 1986), and Leigh (1987), as well as by a new economic study on the effects of mental distress on income by Frank and Gertler (1986). Unemployment apparently results in considerable stress, which can lead to lack of concentration in driving and, ultimately, more fatal accidents. Nevertheless, the policy conclusion of Brenner and others may not apply to reducing highway fatalities. These authors argue that improvements in national health statistics will result from falling unemployment rates. But the effects of falling unemployment are manifold. Falling unemployment results in higher real per capita incomes, which, in turn, lead to higher gasoline consumption and greater driving. The results here suggest that this rising income and increased driving effect is especially pronounced among young men, which unfortunately, will mean more highway deaths. The effects of increased driving more than offset the effects of lower stress due to rising unemployment, so that, on balance, rising unemployment results in fewer highway deaths.

Further empirical studies are needed to determine whether the decreased highway fatalities exceed the increased deaths due to heart and other diseases documented by Brenner, Bunn, and Moser. Probably the answer is no. Estimates from column 2 of Table 2 suggest that a 1 percentage point rise in unemployment will lead to roughly a 3 percentage fall in the fatality rate, that is, fifteen hundred fewer deaths per year. Brenner (1976) claims, more than six thousand disease and suicide deaths result from a 1 percentage point increase in unemployment. Finally (see Joyce et al. 1989), future disease studies should also account for the health effects of increased carbon monoxide due to increased driving resulting from falling unemployment.

Appendix. Summary of Recent Studies

Author(s)	Data	Dependent Variables	Independent Variables
Crandall et al. (1986)	Time series 1947–81	Total deaths, nationwide	Safety index (−), average weight of cars (−), average age of cars, national real income per capita (+), percentage of youths driving, alcohol consumption per capita, average cost of medical care, dummy for embargo years 1974–81, average speed on rural roads, price of motor fuel, share of vehicle miles amassed on limited-access highways, share of truck miles (+), total miles driven (+)
Crandall et al. (1986)	Cross section, 50 states	Total deaths in state	Safety index (−), income per capita (−), percentage of youthful drivers, alcohol consumption per capita (+), average speed, ratios of urban to rural miles driven (−), total miles driven (+)
Zlatoper (1987)	Time series 1956–80	Deaths per capita	Medical costs of accident, consumer real income, time trend (−), alcohol consumption per capita (+), average speed, ratios of youths to adults, accumulation of snow in January, percentage of cars in operation built before 1966 (+) ratios of rural to urban miles driven

Author(s)	Data	Dependent Variables	Independent Variables
McKenzie and Warner (1987)	Time series 1966–84	Total national deaths	Alcohol consumption per capita (+), percentage of female drivers (−), percentage of female drivers(-), percentage younger than 20 in population, ratios of urban to rural miles driven, total miles driven (+)
Wilkinson (1987)	Pooled cross section and time series	Annual fatalities per 1,000 persons over age 15	Alcohol consumption per capita over age 15 (+), percentage of male drivers under age 24 (+), average vehicle speed weighted by number of vehicle miles of travel (+), average standard deviation of speed weighted by vehicle miles of travel (+), variables reflecting probability of arrest and conviction and length of jail term for drunk drivers (+), number of vehicle miles traveled on urban roads per person over age 15 (+), number of vehicle miles traveled on rural roads per person over age 15 (+)
Robertson (many studies summarized in his 1983 book)	Cross section of states in some studies and separate states over time in other states	Fatalities per capita and accidents per capita	Motorcycle helmet laws (−), minimum-drinking-age laws (−), newer, safer cars (−), alcohol consumption (+), percentage of young male drivers (+), car weight (−), miles driven (+)
Fuchs and Leveson (1967)	Cross section 1960, 50 states, $n = 50$	Fatalites per capita	Gas consumption (+), hundreds of persons per square mile (−), percentage of young drivers, mortality rate from other accidents, percentage nonwhite, alcohol consumption per capita, age of car, required eye exam (+) median years of schooling, median income

Appendix continues following page

Appendix. *Continued*

Author(s)	Data	Dependent Variables	Independent Variables
Loeb and Gilad (1984)	Time series in New Jersey only 1929–79, $n = 50$	Raw count of state fatalities	Time trend (−), real per capita income (+), population (+), number of cars registered (+), vehicle inspection (−), World War II years (−), depression years, ratio of vehicle miles to licensed drivers.
Loeb (1985)	Cross section, 50 states and D.C.	Fatalities per capita	Dummy variable for states with vehicle inspection laws (−), percentage of population residing in big cities, fuel consumption per capita (+), personal income per capita, percentage of high-school graduates, percentage of population 18 to 24, percentage population 25 to 44, percentage of population 45 to 64, percentage of population over 64, dummy variable for eye exam requirement, alcohol consumption per capita (+), average annual precipitation (−), total highway miles
Crain (1980)	Cross section, 50 states, excludes D.C.	Fatalities per capita	Population density (−), fuel median income (−), percentage of highways paid for with federal dollars, percentage of young in population, eye and written test, dummy alcohol consumption per capita. Many inspection variables: periodic inspection dummy, biannual inspection dummy, state-owned stations, random inspection dummy
Levy and Asch (1988)	Cross-section, 50 states, excludes D.C. 1985	Fatalities per capita	Miles traveled per driver (+), income per capita, percentage of male drivers (+), percentage of municipal highways, percentage of young drivers, legal driving age, alcohol consumption per capita, mean driving speed (−) variance of speed (−), mean × variance (+)

Author(s)	Data	Dependent Variables	Independent Variables
Lave (1985)	Cross section 21–47 states, excludes D.C.	Fatalities per mile	Mean speed (−), variance speed (+), citations per driver (+), hospital access (−)
Fowles and Loeb (1989)	Cross-section, 44 states excludes D.C. 1979	Fatalities (not per capita)	Minimum legal drinking age, per capita consumption of beer, mean speed (+), variance of speed (+), dummy for inspection (marginal, −, *t*s), hospital access (−), total highway miles, personal income per capita (−), population per square mile (−), percentage young, population (−), miles driven (+)
Partyka (1984)	Annual time series 1960–82, $n = 23$		Number of unemployed, employed, not in labor force
Wagenaar (1984)	Monthly time series, Michigan only, 1972–82		Percentage unemployment, miles driven

Note: (+) indicates that variable was positively correlated with fatalities and statistically significant. (−) indicates that variable was negatively correlated with fatalities and statistically significant.

References

American Automobile Association. 1980. *Digest of Motor Laws, 1976 through 1980.* Falls Church, VA: American Automobile Association.

———. 1981. *World Automobile Yearbook.* Falls Church, VA: American Automobile Association.

Arnetz, B., S. O. Brenner, L. Levi, et al. 1987. Immune Function in Unemployed Women. *Psychosomatic Medicine* 49 (3): 3–12.

Baker, S. P., B. O'Neill, and R. S. Karpf. 1984. *The Injury Fact Book.* Lexington, MA: Lexington Books, D. C. Heath.

Berger, M. C., and J. P. Leigh. 1988. The Effect of Alcohol Consumption on Earnings. *Applied Economics* 20 (10): 1343–52.

Brenner, M. H. 1971. Economic Changes and Heart Disease Mortality. *American Journal of Public Health* 59 (3): 1154–68.

———. 1973. *Mental Illness and the Economy.* Cambridge, MA: Harvard University Press.

———. 1976. Estimating the Social Costs of National Economic Policy: Implications for Mental and Physical Health and Criminal Aggression. Paper No. 5, Report to the Congressional Research Service of the Library of Congress and Joint Committee of Congress. Washington, DC: U.S. Government Printing Office.

———. 1979. Mortality and the National Economy: A Review, and the Experience of England and Wales, 1936–1976. *Lancet* 3: 568–73.

———. 1980. Estimating the Social Costs of Youth Unemployment Problems, 1947–1976. Report of the Vice President's Task Force on Youth Employment Center for Public Service. Waltham, MA: Brandeis University.

Bunn, A. R. 1979. Ischemic Heart Disease Mortality and the Business Cycle in Australia. *American Journal of Public Health* 69 (1): 772–81.

Catalano, R., and D. Dooley. 1983. Health Effects of Economic Instability: A Test of the Economic Stress Hypothesis. *Journal of Health and Social Behavior* 24 (4): 46–60.

Charlton, J. R., H. R. Bauer, and A. Thakhorf. 1987. Unemployment and Mortality: A Small Area Analysis. *Journal of Epidemiology and Community Health* 41 (5): 107–13.

Crain, W. M. 1980. *Vehicle Safety Inspection Systems: How Effective?* Washington, DC: American Enterprise Institute for Public Policy Research.

Crandall, R. W., H. K. Gruenspeeht, T. E. Kealer, and L. B. Lave. 1986. *Regulating the Automobile*. Washington, DC: Brookings Institution.

Cobb, S., and S. V. Kasl. 1977. *Termination—The Consequences of Job Loss*. National Institute for Occupational Safety and Health Publication No. 77-224. Cincinnati, OH: Department of Health, Education and Welfare.

Distilled Spirits Council. 1982. *Annual Statistical Review*. Cleveland, OH: Distilled Spirits Council.

Eyer, J. 1977. Does Unemployment Cause the Death Rate to Peak in Each Business Cycle? *International Journal of Health Services Research* 7 (2): 625–62.

Foege, W. H., S. P. Baker, and J. H. Davis. 1985. *Injury in America: A Continuing Public Health Problem*. Committee on Trauma Research. Washington, DC: National Academy Press.

Fowles, R., and P. D. Loeb. 1989. Speeding, Coordination, and the 55-m.p.h. Limit: Comment. *American Economic Review* 79 (4): 916–21.

Frank, R., and P. Gertler. 1986. The Effect of Mental Distress on Income: Results from a Community Survey. Working Paper Series No. 2433. Washington, DC: National Bureau of Economic Research.

Fuchs, V., and I. Leveson. 1967. Motor Accident Mortality and Compulsory Inspection of Vehicles. *Journal of the American Medical Association* 201 (6): 657–61.

Gravelle, H. S. E., G. Hutchinson, and J. Stern. 1981. Mortality and Unemployment: A Critique of Brenner's Time Series Analyses. *Lancet* 2: 675–81.

Halvorsen, R., and R. Palmquist. 1980. The Interpretation of Dummy Variables in Semilogarithmic Equations. *American Economic Review* 70 (3): 474–75.

Joyce, T. J. 1990. A Time-Series Analysis of Unemployment and Health. *Journal of Health Economics* 8 (4): 419–36.

Joyce, T. J., M. Grossman, and F. Goldman. 1989. An Assessment of the Benefits of Air Pollution Control: The Case of Infant Health. *Journal of Urban Economics* 25 (2): 32–51.

Kasl, S. V. 1979. Mortality and the Business Cycle: Some Questions about Research Strategies. *American Journal of Public Health* 69 (5): 784–88.

Kaufman, B. E. 1989. *The Economics of Labor Markets and Labor Relations*. San Francisco: Dryden Press.

Lave, C. R. 1985. Speeding, Coordination, and the 55-m.p.h. Limit. *American Economic Review* 75 (5): 1159–64.

Leigh, J. P. 1987. The Effects of Unemployment on the Probability of Suffering a Disability. *Work and Occupations* 14 (3): 347–67.

———. 1988. Assessing the Importance of an Independent Variable in Multiple Regression: Is Stepwise Unwise? *Journal of Clinical Epidemiology* 41 (7): 669–77.

Leigh, J. P., and J. Wilkinson. 1988. Estimates of the Elasticity of Highway Deaths with Respect to Gas Price. Unpublished manuscript, San Jose State University.

Levy, D. T., and P. Asch. 1989. Speeding, Coordination, and the 55-m.p.h. Limit: Comment. *American Economic Review* 79 (4): 913–15.

Loeb, P. D. 1985. The Efficacy and Cost-Effectiveness of Motor Vehicle Inspection. *Southern Economic Journal* 52 (2): 505–9.

Loeb, P. D., and B. Gilad. 1984. The Efficacy and Cost-Effectiveness of Vehicle Inspection. *Journal of Transport Economy and Policy* 18 (2): 145–64.

McKenzie, R. B., and J. T. Warner. 1987. The Impact of Airline Deregulation on Highway Safety. St. Louis, MO: Center for the Study of American Business.

Maddala, G. S. 1988. *Introduction to Econometrics*. New York: Macmillan.

Moser, K. A., A. J. Fox, and D. R. Jones. 1984. Unemployment and Mortality in the OPCS Longitudinal Study, *Lancet* 2: 1324–28.

———. 1986. Unemployment and Mortality: Further Evidence from the OPCS Longitudinal Study 1971–1981. *Lancet* 2: 365–66.

Partyka, S. C. 1984. Simple Models of Fatality Trends Using Employment and Population Data. *Accident Analysis and Prevention* 16 (4): 211–22.

Peltzman, S. 1975. The Effects of Automobile Safety Regulation. *Journal of Political Economy* 83 (4): 677–725.

Podgursky, M. J., and P. Swain. 1987. Health Insurance: The Case of the Displaced Worker. *Monthly Labor Review* 110 (4): 230–33.

RATS. 1984. Minneapolis, MN: VAR Econometrics. Robertson, L. S. 1983. *Injuries: Causes, Control Strategies, and Public Policy*. Lexington, MA: Lexington Books, D. C. Heath.

Sass, T. R., and J. P. Leigh. Forthcoming. The Market for Safety Regulation and the Effect of Regulation on Fatalities: The Case of Motorcycle Helmet Laws. *Review of Economics and Statistics*.

U.S. Brewers Association. 1981. *Brewers Almanac*. Milwaukee, WI: U.S. Brewers Association.

U.S. Department of Commerce. 1976–81. *U.S. Statistical Abstract*. Washington, DC: U.S. Government Printing Office.

U.S. Department of Transportation. 1982. *Highway Statistics*. Washington, DC: U.S. Government Printing Office.

Wagenaar, A. C. 1984. Effects of Macroeconomic Conditions on the Incidence of Motor Vehicle Accidents. *Accident Analysis and Prevention* 16 (4): 191–205.

Wilkinson, J. T. 1987. Reduced Drunken Driving: Which Policies Are Most Effective? *Southern Economic Journal* 54 (2): 322–34.

Zlatoper, T. 1987. Testing for Functional Form and Autocorrelation in the Analysis of Motor Vehicle Deaths. *Quarterly Review of Economics and Business* 27 (4): 6–17.