The Effectiveness of Traffic Safety Laws in Reducing Fatal Traffic Accidents: A Reevaluation of State Panel Data

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ABSTRACT

Drunk-driving behavior and its associated costs due to property damage, injury and death has been a central concern for policymakers. Over the past several decades state legislatures have created legal policies, typically based on deterrence theory, that are designed to coerce individuals from engaging in drinking and driving. Using a panel data set of states from 1982 to 2000, this article examines the relative effectiveness of a number of major policies passed by state legislatures. Of particular interest is state laws that lower the threshold of blood-alcohol concentration (BAC) needed to be considered legally impaired (or "per se laws"). Regression results indicate some support for the effectiveness of per se laws that set the threshold at 1.0 BAC, but not for laws that set it at .08. Laws that make servers liable for drunk-driving accidents and beer taxes were also shown to reduce fatal accident measures. An interesting finding was the effectiveness that Mothers Against Drunk Driving (MADD) offices had on fatal accident measures. The implications of these findings are discussed and related to the theory and extant literature. Future research may want to explore the role of exhortative (such as MADD) or cultural explanations of variation in drunk-driving behavior.

Introduction

Drinking and driving continues to be a serious public health concern. According to the National Highway Traffic Safety Administration's (NHTSA) annual report, over 42,500 persons died in roughly 38,000 traffic accidents on America's roadways last year. NHTSA estimates that approximately 40 percent of these fatalities were related to alcohol. Motor vehicle accidents are in fact the leading cause of death for people between the ages of 4 and 35 years old; more than homicides, suicides and diseases. As such, this cause of property damage and personal injury has been an important topic for policymakers and evaluation researchers alike.

While these figures are high, they have been trending downward for the past 40 years. For example, there were more than three traffic fatalities per 100 million vehicle miles traveled throughout the 1970s. The last few years there have been about half as many fatalities (per vehicle miles traveled). Along with this overall decline, the proportion of persons killed in alcohol-involved fatal accidents has also declined noticeably. In the early 1980s the percentage of alcohol-involved fatal crashes was close to 60 percent, while the last few years this figure has been about 40 percent.

A great many possible factors could explain the downward trend in fatal traffic accidents. Public awareness of the risks of driving and advances in vehicle safety technologies are probable explanations. During the same period that the United States witnessed reductions in fatal accidents and alcohol-involved fatal accidents, state legislatures passed numerous traffic safety regulations and launched many initiatives. Moreover, the aggregate reductions observed across the U.S. were not uniform in each of the states. This leads to the question: what effect have laws designed to promote traffic safety had on the number of fatal accidents and alcohol-involved fatal accidents?

This paper examines the effectiveness of traffic safety laws – specifically lowering legal blood alcohol limits – on overall traffic fatalities and alcohol-related accident fatalities. A lengthy body of evaluation research has explored the relationship between traffic safety laws and alcohol control policies on public safety outcomes. This paper follows the rigorous examples of this line of research by analyzing a panel data set of states (1982-200) with number of appropriate control variables. It contributes to the literature by testing the effects of traffic safety laws on fatal accidents by using some alternative outcome and control measures.

Theoretical Framework

Most traffic safety and alcohol control policies are in some way related to general deterrence theory.[1] General deterrence-based policies attempt to compel people from engaging in certain behaviors by increasing the 'costs' or decreasing the benefits of such behaviors. Under deterrence theory, policy-makers seek to compel behavior in three ways: increasing the *certainty* of punishment, increasing the *severity* of a sanction, and increasing the *swiftness* of the punishment.

On average, individuals are less likely to engage in criminal behavior when they perceive that their likelihood of detection is higher and/or when they perceive the punishment to be greater. A drunk-driving control policy, for example, that mandates jail time for first time offenders seeks to compel individuals to refrain from drinking and driving by increasing the costs of this behavior. On the other hand, a law prohibiting driving with an open container of alcohol increases the probability of punishment by making it easier for law enforcement to arrest individuals for driving under the influence (DUI).

Most of the laws or initiatives examined here fit into the deterrence theory framework in some way. Some policies relate directly to the behavior of DUI. For example, illegal *per se* laws – the key policy variable being examined – increase a drunk-driver's probability of being detected, while mandatory jail sentences increase the penalty for drunk driving. Other policies are directed at drinking behavior and as such indirectly pertain to controlling DUI. For example, placing a tax on beer, wine and liquor is first expected to decrease consumption and then the related behavior of drinking and driving. The effect of Mothers Against Drunk Driving, an organization that works to exhort drivers to engage in less risky behavior, is also analyzed here. While this organization engages in many different kinds of activities, its role in terms of deterrence theory is to inform people about the costs and influence people's values towards drinking and driving. As the next section discusses the empirical evidence around the effectiveness of relevant traffic safety laws, it will also highlight how each particular policy relates to the deterrence theory framework.

Empirical Evidence

This paper is concerned with evaluating the effectiveness of illegal per se laws, a type of traffic safety law that legislatures and even Congress have debated. These laws establish a blood alcohol concentration (BAC) that is illegal "per se" – or by itself. The "per se" refers to the fact that a BAC above the legal limit is direct evidence that the driver is guilty of driving under the influence. Prior to illegal per se laws, law enforcement officers would have to present behavioral evidence (i.e. from field sobriety tests) in an effort to prove the driver was impaired by alcohol. States first established illegal per se BAC limits at 1.0. Later, in response to both political pressure and some scientific evidence that driving skills diminish at lower BAC levels, some states began to pass legislation making it illegal per se to drive with a BAC greater than .08.

Illegal per se laws are expected to increase the probability of sanctioning an intoxicated driver. Under any illegal per se law, impairment is assumed automatically based on the objective BAC of the driver. Regardless of a driver's subjective appearance of "drunkenness" or ability to perform the tasks of a field sobriety test, a driver with a BAC above the legal limits is effectively guilty of driving under the influence of alcohol. Furthermore, establishing or lowering the per se limit to .08 expands the definition of behaviors defined as illegal. For example, prior to an illegal per se law of .08 in a state, people could drive with BAC levels of 0.09 so long as the law enforcement officer could not detect impairment. Thus, illegal per se laws hope to deter people from driving while intoxicated and as such reduce the negative outcomes associated with this behavior (property damage, injuries and deaths).

A number of empirical studies have evaluated the effects of illegal per se laws on various traffic safety outcomes, such as fatal accidents. Early research on the effectiveness of these laws used simple pretest-posttest designs either with or without comparison groups. For example, one study of California found significant reductions in alcohol-related fatal accidents after the implementation of an illegal per se law, but a follow-up study could not conclude that reducing the legal limit to .08 was effective.[2] Hingson, Heeren and Winter expended the evaluation design by pairing five states that adopted .08 per se laws with five similar states with 1.0 per se laws.[3] They found that the law led to reductions in the proportion of fatal accidents that involved alcohol from pretest to posttest in four of the five pairings. Another study examined the effect of creating a zero-tolerance BAC level (i.e. >.01) for youths and found that states with lower legal limits for youths had a greater reduction in the proportion of youth involved in fatal accidents compared to matched comparison states.[4] As a General Accounting Office's review of the literature prior to 1999 observed, the results of these studies present a mixed picture of the effectiveness of illegal per se laws.[5] Moreover, the review correctly questions the validity of these findings for several reasons, including failure to control for underlying time-trends, the quality of comparison states, and omitted variables.

Panel Design Studies. Since the GAO review of the literature, several studies have re-examined the effects of per se laws on traffic safety outcomes using stronger panel designs. An early study not included in the GAO review found that per se laws had no significant effect on alcohol-related accidents in a panel state-level data.[6] This study used the fewest controls of any of the panel design studies, however. Using a panel of the 48 contiguous states from 1982-1998, Dee found that per se limits of .08 BAC and 1.0 BAC significantly reduced the fatal accident rate (per population).[7] Another study using a similar set of data, but with additional controls for aggregate alcohol consumption and religions, found no significant effects on alcohol-involved fatal accidents.[8] This study did not differentiate between 1.0 BAC laws and .08 BAC laws. Another study conducted by NHTSA staff employed a panel design to estimate the effects of per se laws in all fifty states from 1982 to 1997.[9] Here, NHTSA found that establishing illegal per se limits resulted in a reduction in the proportion of alcohol-involved fatal accidents. Finally, the most recent study conducted by Eisenberg found that state per se .08 laws significantly reduced fatal accident rates, alcohol-related fatal accident rates and other proxy measures for alcohol-related accidents.[10] However, per se 1.0 BAC laws only demonstrated significant reductions on alcohol-related accident rates. While this study used a longer period (1982-2000) and controlled for a number of relevant policy and economic variables, it did not use any control measure for drinking sentiment or consumption as in the Mast, Benson, and Rasmussen analysis.[11] All of the studies discussed here used both state and year fixed effects.

Overall, the empirical evidence on the effectiveness of illegal per se laws remains mixed. Two of the panel design studies observed no significant reductions fatal accident measures.[12] Three other designs found that illegal per se laws significantly reduced fatal accidents.[13] It is difficult to compare across these studies because they sometimes used several different analytic techniques, slightly different dependent variables, different control variables and different time frames. For example, we cannot be sure that the negative effect observed in Eisenberg,[14] compared to Mast, Benson and Rasmussen,[15] was the result of failing to control for drinking sentiment or for adding two more years of data and including Alaska, Hawaii and the District of Columbia in the analysis. The present study uses the Eisenberg data set,[16] with slight modifications to both data and model specification, to reevaluate the effect of per se laws on fatal accidents and alcohol-related fatal accidents.

Empirical evidence for other state laws

There are numerous state laws aimed at reducing drinking, drinking and driving or promoting safe driving behaviors (i.e. seat belt use). A large body of evaluation research, using a variety of designs and measures, has examined the role of many of these traffic safety laws. Focusing primarily on the policy variables included in the present analyses, the following briefly discusses a selection of this literature.

Two laws are basically designed to raise the punishment for engaging in drinking and driving. First, several studies have evaluated the effects of administrative license revocation (ALR) laws. These laws allow the state to revoke or suspend a driver's license if arrested while driving under the influence of alcohol, regardless of the outcome of the trial. The evaluation research has shown ALR to be a promising policy lever for reducing various fatal accident or drunk-driving outcomes.[17] Second, the effects of mandatory jail (or community service) for first time offenders has at best mixed results in the evaluation literature. The two strongest designs reported no significant effects for these laws;[18] while a panel design with limited controls found a reducing effect on fatal accidents.[19] Kenkel, using a national cross sectional survey found that self reported drinking and driving behavior was lower in states with mandatory jail provisions than in states without these provisions.[20]

Both open container laws and preliminary breath test laws are designed to make it easier for law enforcement officer to detect drunk-driving behavior. Although open container laws increase the punishment as well, they increase the probability of detection because a law enforcement official would be able to arrest an individual for the open container before he or she has detected actual driver impairment. Similarly, preliminary breath test laws allow an officer to give a breath test of a driver prior to making a lawful arrest for DUI. In the two studies that examined these laws, preliminary breath test laws have demonstrated no significant impact on fatal accidents, while open container laws have been shown to significantly reduce the fatal accident rates.[21]

Three laws that target alcohol consumption that are included in this analysis are dram shop liability laws, beer taxes and changes in the minimum legal drinking age. By allowing individuals harmed by drunk drivers to sue the servers of the drunk driver, the goal of dram shop laws is to compel alcohol servers to pay attention to the drunkenness of their clientele and therefore reduce drunk driving. Evaluation research for the most part has found that these laws are an effective mechanism for reducing fatal accidents and alcohol-related fatal accidents.[22] The effect of beer taxes has been debated in the literature. While early cross sectional studies and one panel design[23] suggested that beer taxes could have powerful deterrent effect on consumption and drunk-driving, Mast, Benson, and Rasmussen (see also Dee, 1999) found that using a panel design and controlling for sentiment eliminated the effect of beer taxes on both consumption and alcohol-related fatal accidents.[24] Eisenberg's study found beer taxes significantly reduced fatal accidents, but he did not control for drinking sentiment in any way or the price of alcohol.[25] The effect of increasing the minimum legal drinking age above 18 has also shown mixed results in the evaluation literature. Perhaps the relative effectiveness of dram shop laws, compared to other alcohol-control policies, is that they directly target drinking behavior that occurs away from a person's home.

Methodology

To evaluate the effect of state traffic safety laws on fatal traffic accidents, data were collected on a panel of all states and the District of Columbia for each year from 1982 to 2000. As such, the unit of analysis is a state-year, with 969 observations (51 states X 19 years). Daniel Eisenberg originally constructed most of this data set using the following governmental sources: National Highway Traffic Safety Administration (website, correspondence, *Annual Digest of State Alcohol-Highway Safety Related Legislation*, 1982-2000), Census Bureau, Bureau of Labor Statistics, and the Bureau of Economic Analysis. Other nongovernmental sources include the Beer Institute's *Brewers Almanac* (for beer tax information), and direct correspondence with Mother Against Drunk Driving. The few changes and additions that were made to these data will be noted in the discussion of measures.

Outcome Measures

The outcome variables are drawn from the National Traffic Highway Safety Bureau's (NHTSA) Fatal Accident Reporting System (FARS) data. Established in 1975, this system uses police reports, hospital records and other sources to track information about the extent and nature of fatal accidents across the country. FARS data has been widely used in governmental evaluations and scholarly research. Since there are few sources measuring actual drunk driving behavior, the fatal accident outcomes produced by FARS are the best available outcome data.

A number of traffic safety outcome measures can be developed using the FARS data. This study uses three outcome measures: 1) total number of fatal accidents, 2) number of drunk-driving related fatal accidents, and 3) the number of high BAC drunk driving related accidents. Table 1 provides the descriptive statistics for the measures. Measures similar to the first measure – total fatal accidents – are widely used measure in evaluation research. While it is not directly related to any particular policy, it is a broad and reliable measure of the outcome state laws and traffic safety initiatives hope to achieve: saving lives.

Table 1: Descriptive Statistics for Outcome Measures

	Mean	SD	Min	Max
Number of fatal accidents	751.95	770.82	34	4935
Number of high BAC level accidents (over 1.0 BAC)	246.60	272.37	6.92	1858.01
Number of any BAC level accidents (over 0.0 BAC)	305.44	337.88	12.95	2276.04

The second two measures – any alcohol related fatal accidents and high alcohol related fatal accidents – are more directly related to the key traffic safety laws being evaluated in the paper. FARS collects the blood alcohol content of drivers involved in fatal accidents through autopsy reports and police records. However, the FARS data do not always capture the driver's blood alcohol content, particularly in early years of the reporting system. Klein[26] developed an imputation procedure to estimate the driver's BAC, which has been used in several evaluation studies.[27] These data also used the imputation method to construct the drunk-driving fatality outcomes. While the field accepts this imputation procedure to be a valid estimation of drunk-driving related accidents, systematic bias in reporting of BACs by state may bias the results presented here if it is associated with policy variables. The results of all three outcome measures are used to identify consistent findings.

Counts and Rates. Past studies of traffic safety laws have used rate-based measures for outcome variables. For example, the study partially being replicated here used the number of fatalities per drivers as dependent variable.[28] While it is appropriate to control for drivers in some way, it is not necessary to use it in the denominator of the dependent variable. It unnecessarily makes assumptions about the relationship between drivers, vehicle miles and fatal accidents. Further, using the number drivers as a denominator in the dependent variable may exacerbate simultaneity bias when it is also used to calculate independent variables. For these reasons the current analysis uses a straight count of fatalities as a dependent variable.

Several alternative outcome measures are not used in the present analyses. Due to potential problems with imputing the BAC levels of drivers, several studies have used other proxies for drunk driving, such as single vehicle accidents and single vehicle accidents that occur at night.[29] Dee and Eisenberg sometimes found similar results using both the imputed BAC and the other proxy measures.[30] Other studies have focused on youths by using total youth fatal accidents and drunk-driving accidents among youths since some laws (graduated licensing initiatives and zero tolerance laws) target youth behavior only.[31]

Independent Measures

Over the past three decades numerous state laws have been passed in an effort to promote traffic safety and save lives. This study measures some of the most common of these laws. Each law is measured using a dummy variable indicating whether or not the state law was in place for each state-year (0=no, 1=yes). In the event that a state law became effective at some point during the middle of a year, a proportion was constructed to reflect the proportion of the year in which the law was in effect. For example, a state law with an effective date of September 1st would be coded as .25 for that state-year. Table 2 presents the descriptive statistics for each of the independent measures.

Table 2: Descriptive Statistics

Countermeasures	**Mean**	**SD**	**Min**	**Max**
Illegal per se 1.0 BAC limit	.73	.43	0	1
Illegal per se .08 BAC limit	.14	.34	0	1
Zero tolerance	.29	.44	0	1
Administrative license revocation	.55	.49	0	1
Minimum legal drinking age 21	.85	.35	0	1
Preliminary breath test	.51	.50	0	1
Mandatory jail for 1st offense	.30	.46	0	1
Dram shop liability	.81	.39	0	1
Open container law	.47	.50	0	1
Secondary seat belt	.48	.49	0	1
Primary seat belt law	.147	.35	0	1
Graduated license program	.04	.19	0	1
Beer tax (cents per gallon)	31.48	25.42	1.90	137.05
Number of MADD offices	4.46	4.55	.0	21.0
Control Variables	**Mean**	**SD**	**Min**	**Max**
Number of Drivers (1,000s)	3329.17	3552340.84	258061	21243940
Vehicle miles	42.69	45378.83	3099	306649
Average age (over 16)	34.75	1.79	27.5347	39.10
Real per capita income	24.11	4.53	14.42	41.20
Unemployment rate	6.08	2.21	2.2	18.0
Land area (sq. miles)	69361.54	84895.82	61.40	571951.26
Total population	4959555.82	5449134.07	449611	33871648
Population density	352.65	1334.26	.79	10395.41

BAC Laws. Given the recent attention to changes in the legal BAC limit, the key policy variable in this study is the variable indicating the state laws that make driving with a BAC level above .08 illegal '*per se.*' Prior to 'per se' legislation in a state, it was illegal to drink and drive but only based on behavioral evidence collected from a law enforcement officer. Per se laws, make it illegal to drink and drive if ones blood alcohol level is above a legislatively defined BAC.

During the period reflected in the data, many states initially passed legislation making it illegal to drive with a BAC above 1.0. Later, states began to pass stricter legislation that made it illegal to drive with a BAC over .08. Two variables reflect these pieces of traffic safety legislation in the data.

Other DUI related law. There are several laws directly related to deterring or preventing the occurrence of drunk driving and, as such, fatal accidents. Administrative license revocation (ALR) provisions make it possible to revoke a person's license automatically for failing a breath test. These kinds of laws essentially add a punishment to drunk driving that does not depend on the outcome of a hearing or trial. Preliminary breath test laws (PBT) allow law enforcement officers to test the driver's alcohol BAC through a breath test prior to making an arrest. Related to deterrence theory such laws hope to increase the probability of punishment: If a law enforcement officer can test for alcohol usage without having to first meet the requirement for a lawful arrest, the likelihood of detecting impaired drivers increases. While differing in severity of punishment across states, many states have passed laws that make it (virtually) mandatory to serve a jail sentence for even the first drunk driving offense.

Two economic policy levers are aimed at drinking. First, dram shop laws make it possible for private establishments (bars, restaurants, sporting venues etc) to be liable for damages of any accidents caused by impaired patrons. Basically, dram shop laws place some of the costs of accidents on the servers of alcohol, which would in turn compel them to serve alcohol to patrons more responsibly. States have also passed beer taxes that are aimed at reducing consumption of beer. One of the intended benefits of reduced beer consumption is a reduction in drunk driving and related accidents. In the data, this variable is measured as the tax (in real 1999 cents) on a gallon of beer for each state-year.

States also have passed laws targeted at improving the safety of teenage drivers. Young drivers comprise a disproportionate number of traffic fatalities and alcohol-related traffic fatalities.[32] Like "per se" laws that make it illegal to drive above a certain limit for all drivers, "zero tolerance" laws create an extremely low BAC threshold for drivers under 21 years of age. The idea behind such legislation is that since these drivers cannot drink legally, driving with any alcohol in ones blood should be strictly prohibited. Another type of law targeted at youthful drivers is initiatives that gradually integrate teenagers into driving. Such "graduate license programs" usually start new drivers with restricted driving privileges (i.e. only with adults, no late night driving) so that they can build up experience before becoming full drivers. Finally, in the early 1980s many states raised their minimum legal drinking age to 21 years old (either voluntarily or after being compelled by the federal government). Now all states have such provisions. While this analysis does not have an outcome variable that measures directly young driver accidents, these laws should be controlled for because they could affect the overall outcome measures.

Most states have laws mandating the use of seat belts. Two basic kinds of laws exist: primary and secondary. Primarily seat belt laws allow law enforcement officers to stop a driver and issue a citation for not wearing a seat belt, while secondary laws allow officers to issue citations to drivers not using seat belts only after being pulled over for some other driving offense. Eisenberg uses a single variable measuring "any" seat belt law.[33] This analysis uses two dummy variables for each type of seat belt law.

Finally, this analysis uses a variable measuring the number of MADD offices present in a state-year. While not a state law or initiative, MADD offices engage in a variety of activities that are thought to prevent drunk driving. This study uses a different measure of MADD from the only other study to examine the affect of MADD.[34] Instead of using the rate of MADD offices per one million drivers, this study uses the simple count of MADD offices. There seems to be no solid theoretical justification for constructing a rate of MADD offices. This study argues that population size does not inhibit some of MADD's "treatments," as a mass awareness campaigns and other specific activities that then receive publicity.

Control Variables. Past research has demonstrated that a number of important variables must be controlled for in order to isolate the effects of traffic safety regulations on fatalities. Variables, such as number of license drivers and vehicle miles driven, control primarily for a state-year's 'opportunity' for having fatal accidents occur. Some states simply have more drivers and more vehicle miles driven than other states. Number of vehicle miles (in 1000s) and number of drivers (in 1000s) will be used as control variables. The reason for using these as controls, rather than as a denominator in the dependent variable was discussed above.

Driver's age is negatively related to fatal accident involvement, but not necessarily in a linear direction. Young drivers, due in part to both risky behavior and inexperience, are at greater risk for fatal accidents.[35] Yet older persons are also more likely to experience a fatal crash, perhaps due to declining reaction time. Middle aged drivers however, experience the lowest rate of traffic fatalities. As such, the state-year's mean age and mean age squared will be included as controls in the model.

Interestingly, economic variables tend to have a positive relationship with traffic fatalities. As incomes increases the opportunity to spend more on drinking increases, particularly drinking at restaurants, bars, concerts and sporting events where driving is necessary. This study uses per capita income (in real 2000 dollars) and the unemployment rate for each state-year to capture economic well-being.

Finally, characteristics about the roadways in a state probably influence the number of accident fatalities that occur. This study uses population density as a rough measure of the road types or road density beyond the number of drivers.

Analytic models

Generalized Least-Squares regression models are used to estimate the effects of policy variables on the state-year fatal accident outcome measures. Fixed-effects are used for each state to capture unobserved variables. In addition, rather than using a trend variable to control for changes over time, this analysis uses year fixed effect dummies because it makes no assumptions about the linearity of the underlying trend. Formally the model is as follows:

$$Y_{it} = a + b_1X_{it} + b_2Z_{it} + b_3D_i + b_4D_t + e_{it}$$

Y_{it} is the number of fatal accidents or number of alcohol-related fatal accidents for each state (i) and year (t). A second set of models will use the natural logarithm of Y_{it} as dependent variables. X refers to the two independent variables of interest: illegal per se .08 BAC and 1.0 BAC laws. Z refers to the other policies believed to affect the outcomes. D_i is a vector of state dummy variables, and D_t is the vector of year dummy variables (each not reported in the results). Since the error terms are likely correlated over time within each panel, the models make adjustments for first order autocorrelation. Additionally, it was assumed that these data are heteroscedastic, so the analysis estimates robust standard errors.

Results

Count Outcome Model Results

Table 3 displays the coefficients and standard errors from the GLS regression results with fixed effects. The bold coefficients with asterisks (*) are statistically significant using a one-tailed test of significance (at the .05-level). Three models are presented: Model 1 presents the results predicting the number of fatal accidents, Model 2 presents the results for the number of fatal accidents involving any amount of alcohol and Model 3 presents the results for the number of fatal accidents involving high degrees of alcohol use (over 1.0 BAC).

Table 3: Results of GLS Regression on Fatal Accident Outcomes (N=969)

	Model 1: Fatal Accidents (#)		Model 2: Alcohol Related Accidents (#)		Model 3: High Alcohol Related Accidents (#)	
	b	s.e.	b	s.e.	B	s.e.
Countermeasures						
Per se .08	-14.79	12.69	-11.44	8.01	-5.83	6.77
Per se 1.0	**-26.02***	**8.12**	**-11.14***	**5.25**	**-7.44***	**4.44**
Zero tolerance	4.58	5.86	-3.17	3.79	-1.37	3.16
License revocation	-3.00	5.85	0.63	3.80	-1.14	3.20
Mandatory jail	11.20	8.81	-4.03	5.75	-3.54	4.93
Prelim. breath test	9.13	10.99	-3.21	7.08	.20	6.25
Dram shop liability	**-18.76***	**9.86**	**-15.22***	**6.53**	**-16.75***	**5.47**
Open container	-8.12	8.91	-0.19	5.38	2.99	4.44
Legal age 21	6.70	6.43	3.64	4.11	-1.51	3.40
Beer tax (cents)	**-2.36***	**0.37**	**-0.73***	**.24**	**-.76***	**.21**
Primary seat belt	**-27.02***	**10.08**	**-11.69***	**6.25**	-8.22	5.42
Secondary seat belt	7.38	6.41	5.87	4.07	5.56	3.39
Grad. Licensing	-2.91	10.58	-7.47	6.76	-7.20	5.52
MADD offices (#)	**-9.68***	**1.78**	**-6.61***	**1.18**	**-5.99***	**.99**
Controls						
Income rate	**9.88***	**2.18**	**3.77***	**1.41**	**3.63***	**1.20**
Unemployment rate	**-8.20***	**1.62**	**-3.62***	**1.02**	**-2.79***	**.86**
Avg. age	71.11	45.26	53.37	30.98	**45.61***	**26.32**
Avg. age squared	-0.86	.68	-0.72	.46	-.61	.39
Population density	0.01	.03	-.008	.02	-.002	.01
Drivers (1,000s)	.007	.013	-.010	.01	-.01	.007
Vehicle miles (1,000s)	.0008	.0007	**-.003***	**.001**	**-.003***	**.001**

Notes: Fixed effects for state and year included, but not reported here.
Bold (*) = p<.05; one-tailed test.

Model 1. The results for Model 1 indicate that having a 1.0 BAC limit significantly reduces traffic fatalities, while having the stricter .08 BAC limit shows no significant reduction. State-years where a 1.0 BAC limit was in effect had, on average, 26 fewer traffic fatalities after controlling for other factors. This finding is interesting because it shows that the stricter per se limit did not significantly impact traffic fatalities after controlling for the 1.0 per se limit. This finding is not consistent with earlier studies.[36] The effect of .08 BAC limit is negative, however, and multicolinearity may have impacted the hypothesis test by inflating the standard errors.

Among the other countermeasure variables, laws making private establishments liable for drunk-driving deaths and beer taxes reduce the number of traffic fatalities. The results indicate that states with "dram shop" liability laws have nearly 19 fewer traffic fatalities compared to states that do not have such provisions. From these data beer taxes appear to have a powerful effect on the number of traffic fatalities. Each penny increase in the state beer tax prevented 2 fatal accidents per a year. More perhaps needs to be done to evaluate the true effect of this variable. As Mast, Benson and Rasmussen argue, beer taxes are only a small percentage of the overall cost of beer.[37] As such, a better measure would take into account the total average cost of beer (and other alcohol) to evaluate the marginal benefit of beer taxes in terms of fatal accident prevention. Overall the this study found that economic "levels" that seek to reduce drinking through increasing the costs of this behavior have promising effects on reducing fatal accidents. However, controls for drinking sentiment and the levels of actual consumption probably affect the robustness of this finding.[38]

Primary seat belt laws – that compel drivers to use seat belts – also reduce the number of traffic fatalities in a state-year. On average, state-years where a primary seat belt law was in effect had 26 fewer fatal accidents than state-years where without a primary seat belt law. Previous studies have examined the "offsetting" effect that seat belt laws may introduce. They argue that seat belt laws may cause drivers to drive more recklessly.[39] While this study does not measure the degree of offsetting that occurs, it found that the safety effect of seat belt laws washes out any offsetting effect. After all for offsetting to occur in any substantial way, one has to believe that the same driver chooses to engage in a rather cautious behavior (driving with a seat belt, obeying the seat belt) law and then simultaneously engages in risky behavior (reckless driving).

One final, but interesting, finding is the effect of MADD offices on fatal accidents. Using the number of MADD offices per drivers, Eisenberg found no significant effects on fatal accidents.[40] This analysis – using a simple count measure – found that the number of MADD offices in a state-year significantly decreased the number of fatal accidents. Each additional MADD office in a state appears to reduce fatal accidents by 9 each year. A change in the way this variable was measured and slightly different method of analysis seems to have produced different results.

It is important to examine how well significant findings hold up using multiple outcome measures. Recall that Model 2 uses all alcohol-related accidents as an outcome measure and model 3 uses alcohol-related accidents with BAC levels over 1.0 (or "high" alcohol-related accidents). These results are present in columns 3 thru 6 of Table 4.

The results of these analyses provide further evidence that certain countermeasures influence fatal accidents. Laws that set the legal BAC limits at 1.0 continue to demonstrate significant life saving effects in both Models 2 and 3. The results of these additional analyses also show that beer taxes and dram shop liability laws have consistent effects on reducing fatal accidents. In addition, the effect of state MADD offices did not go away when a different measure of fatal accidents were used. Primary seat belt law was the only variable that did not have consistently significant effects across all three models: significant effects were not found when the model used high alcohol related accidents as an outcome.

Examining the impact of the significant countermeasure variables across the three outcome variables, one might notice a peculiar finding. The effect sizes of countermeasure variables are bigger for the overall accidents model than they are for all drunk-accidents model and the high-drunk accidents model. This finding seems counter intuitive. One would expect that policies designed specifically to reduce drunk driving accidents would have their greatest impact on fatal accidents related to drunk driving, rather than all fatal accidents in general. While a number of reasons may explain this, one plausible explanation for this is that there is a great deal more variation in the first overall accident outcome variable compared to the alcohol related accident variables. To explore these relationships some more and to examine whether a change in functional form changes the results, secondary analyses were conducted using a logged set of dependent variables.

Logged Outcome Model Results

Using logged dependent variables, a number of variables have significant negative affects on overall fatal accidents (Model 4), including: 1.0 BAC laws, seat belt laws (both primary and secondary), graduated licensing programs, the number of MADD offices, beer taxes and dram shop liability laws. The logged dependent variable means that the coefficients need to be interpreted as a percent change in fatal accidents, per one unit change in the independent variable. So for example, Model 3 suggests that per se BAC 1.0 laws reduce fatal accidents by roughly three percent (.029 x 100 = 2.9%). Interestingly, preliminary breaths test laws, have a significant *positive* effect in this model. Models 4 and 5 suggest that license revocation laws significantly reduce traffic fatalities, while the effect of secondary seat belt laws and graduated licensing programs are no longer significant.

Table 4: Results of GLS Regression on Logged Fatal Accident Outcomes

	Model 4: Fatal Accidents (ln#)		Model 5: Alcohol Related Accidents (ln#)		Model 6: High Alcohol Related Accidents (ln#)	
	b	s.e.	b	s.e.	B	s.e.
Countermeasures						
Per se .08	-.029	.018	-.038	.027	-.036	.029
Per se 1.0	**-.029***	**.013**	-.022	.018	-.014	.020
Zero tolerance	.013	.009	-.022	.014	-.014	.015
License revocation	-.014	.009	**-.034***	**.013**	**-.038***	**.014**
Mandatory jail	.010	.015	-.015	.019	-.022	.020
Prelim. breath test	**.050***	**.015**	**.045***	**.020**	**.042***	**.021**
Dram shop liability	**-.031***	**.014**	**-.049***	**.022**	**-.053***	**.023**
Open container	-.013	.011	-.022	.018	-.007	.019
Legal age 21	.007	.011	**.042***	**.017**	.002	.017
Beer tax (cents)	**-.003***	**<.001**	**-.002***	**<.001**	**-.003***	**.001**
Primary seat belt	**-.052***	**.015**	**-.049***	**.023**	**-.057***	**.024**
Secondary seat belt	**-.017***	**.010**	-.001	.015	.002	.016
Grad. Licensing	**-.024***	**.013**	-.036	.021	-.034	.024
MADD offices (#)	**-.011***	**.002**	**-.009***	**.002**	**-.009***	**.003**
Controls						
Income per capita	**.026***	**.004**	.006	.006	.007	.006
Unemployment rate	**-.019***	**.003**	**-.030***	**.004**	**-.030***	**.004**
Avg. age	**.379***	**.090**	**.335***	**.144**	**.304***	**.147**
Avg. age squared	**-.006***	**.001**	**-.005***	**.002**	**-.005***	**.002**
Population density	9.77e-06	<.001	**-3.38e-4***	**<8.76e-5**	**-3.97e-4***	**1.25e-4**
Drivers (1,000s)	**2.8e-05***	**<.001**	1.02e-5	1.83e-5	6.62e-6	1.18e-5
Vehicle miles (1,000s)	4.38e-7	<.001	**2.30e-6***	**1.12e-6**	**2.40e-6***	**1.15e-6**

Notes: Fixed effects for state and year included, but not reported here.
Bold (*) = p<.05; one-tailed test.

Are the effects of countermeasure variables still strongest for the broadest outcome measure (all accidents) than they are for the alcohol-related accident outcomes? The answer is in part yes and in part no. For some measures we observe the same pattern that occurred in the previous count based model. For instance, per se 1.0 BAC laws are significant for the all fatal accident measure, but not significant for the other measures and the coefficients are smaller. However, other variables produce results that fit the pattern we might expect to find: bigger effects on alcohol-related accidents and a smaller effect on all types of accidents. For example, dram shop liability laws seem to have their greatest impact in reducing alcohol-related crashes. The models suggest that dram shop liability laws reduce alcohol related accidents by about five percent and all accidents by about three percent. Similarly, the effect of administrative license revocation laws is small and not significant in Model 4, but much larger and statistically significant in Models 5 and 6.

Summary

Looking across the six models there are several variables that have consistent results. Table 5 illustrates the findings across the six models examined here. A negative or positive sign means that the result is significant in the indicated direction (one-tail, $p<.05$), while a blank indicates no significance. First, the two economic policy "levers" – dram shop liability laws and beer taxes – remain significantly negative for both functional forms and all dependent variables. Using different analytic technique (weighted least squares with fixed effects) and rate outcomes, Eisenberg (2003) found that dram shop laws also significantly reduced all three outcomes. Next, the number of MADD offices is the only other countermeasure variable that demonstrated consistent results across the models. Whether the outcome measures are logged or a count did not change the significance of MADD's effect on traffic accident fatalities.

Several variables are significant only when logged outcome measures are used. Secondary seat belt laws and graduated license programs display significant negative affects on accidents (logged), which was not the case when the outcome is measured as a simple count. This was only for the overall fatal accident measure, however. In addition, license revocation laws appear to reduce alcohol related accidents ('any' and 'high') when the analysis uses a logged dependent variable.

Table 5: Summary of Significant Regression Results Across Six Models

	Models w/ Count Outcomes			Models w/ Logged Outcomes		
	(1)	(2)	(3)	(4)	(5)	(6)
Countermeasures						
Per se .08						
Per se 1.0	—	—	—	—		
Zero tolerance						
License revocation					—	—
Mandatory jail			—			
Prelim. breath test				+	+	+
Dram shop liability	—	—	—	—	—	—
Open container						
Legal age 21					+	
Beer tax (cents)	—	—	—	—	—	—
Primary seat belt	—	—		—	—	—
Secondary seat belt				—		
Grad. Licensing				—		
MADD offices (#)	—	—	—	—	—	—
Controls						
Income per capita	+	+	+	+		
Unemployment rate	—	—	—	—	—	—
Avg. age			+	+	+	+
Avg. age squared			+	—	—	—
Population density					—	—
Drivers (1,000s)				+		
Vehicle miles (1,000s)		—	—		+	+

Notes: "–" indicates a significant negative effect using a one-tailed test ($p<.05$).
"+" indicates a significant positive effect using a one-tailed test ($p<.05$).

Discussion

This study examined the effectiveness of state traffic safety policies on fatal traffic accident outcomes, with specific interests on illegal per se laws. It used a panel design of all states and the District of Columbia from 1982 to 2000. The main difference between this evaluation and past evaluations is that it used the number of fatal accidents as the basic dependent variable, rather than a rate-based measure (i.e. accidents/population or accidents/vehicle miles traveled). The results suggest that per se 1.0 BAC limits can reduce fatal traffic accident and alcohol related traffic accidents. The stricter per se law (.08 BAC limit), however, failed to display a significant impact over and above its counterpart per se law. Additionally, using a logged dependent measure changed the significance of the per se 1.0 BAC limit. With this caveat in mind, the findings presented here add to the some of the findings in the existing literature that per se laws can improve public safety on the roadways.

Beyond the findings of the illegal per se laws, three variables – beer taxes, dram shop laws, and the number of MADD offices – were robust across all dependent measures. The finding here on dram shop liability law adds to the consistent findings from prior research that dram shop laws are a promising policy. The effect of beer taxes has not been consistent in the literature and this study suffers from the same missing variable bias that has limited other significant findings. While the effect of MADD observed here could be due entirely to the method constructing the dependent variable, this finding is nonetheless an important variable to be considered in the future. Promoting MADD or similar non-profit organizations may be a cost effective way of advancing highway safety.

Limitations and Future Research

A number of limitations threaten the validity of the findings. First, there are several factors omitted here that may explain variance in fatal accidents. One of the more salient missing variables is state social culture around issues of alcohol use. Due to some cultural norm some states may have far less alcohol use and therefore fewer fatal accidents. These states may also be the states to pass strict drunk-driving and alcohol consumption regulations. One study on the effect of beer taxes attempted to capture cultural factors using a measure of religiosity and found a significant relationship with alcohol-related accidents and consumption.[41] While this study uses fixed effects for the state and the year, it is possible that this does not control sufficiently for cultural differences. Indicators of cultural norms, then, may wash out the effects of drunk-driving control policies observed here. Future research should work to incorporate some measure of cultural norms.

There are clearly many other variables missing from this analysis that might bias parameter estimates. Indicators of weather, extent of public transportation, road types, and enforcement all may influence the number of fatal accidents and alcohol-related accidents. For example, the rigor in which police agencies enforce traffic laws, and particularly drunk-driving laws, increases a driver's probability of being caught. Based on deterrence theory we would expect that this would decrease a driver's likelihood of engaging in this behavior. While the list of missing variables could go on indefinitely, future researchers should seek to identify the more salient variables for inclusion, particularly as longer panels of data become available.

This study also found that MADD offices had a rather strong effect on fatal accidents. However, because this study uses a crude measure (number of offices) it is unclear what types of MADD activities truly prevent fatal accidents. Future studies may seek to unpack the effect of MADD on fatal accident outcomes. Since media campaigns, coupled with targeted enforcement, appear to be the popular strategy with the federal government (NHTSA website), future research should be aimed at measuring the extent of public awareness advertising. Such future research would be valuable for both MADD (which often partners with law enforcement agencies) and the federal government to allocate resources.

Two types of simultaneity issues threaten the validity of the parameter estimates found here. First, there may be a regression to the mean effect that is also related to the introduction of traffic safety regulations. After a particularly high spike in fatal accidents and particularly drunk driving accidents, state legislators may be motivated to pass new alcohol control or traffic safety laws. Any following reduction in the fatal accidents that follows may simply be attributed to a reaction on the part of drivers to be more cautious out of fear, rather than any deterrence effect of legislation. The results presented here suggest that certain types of legislation cause reduction in traffic fatalities. However, the relationship between the policy variables and fatal accidents may be bidirectional: the level of fatal accidents may cause legislation. Therefore, if this were the case the results found here may be overestimated.

This simultaneity issue has plagued the research around traffic safety policy. Like the analyses presented here, most studies have not employed any modeling techniques to help eliminate this limitation. Eisenberg was one of the first studies to attempt to address this issue directly through the use of a lagged effect model.[42] He found this qualified some of the direct effects observed in the original model. While a lagged effect model does shed some light on the simultaneity issue, it is not the ideal method for accounting for this problem. An analyst must guess at what lag is most appropriate or test multiple lags, which may result in a form of "data mining." A more appropriate method may be a two-staged least squares model. The problem with using such a model, which probably explains the reason it has not been used in the literature, is that the analyst needs to specify an instrumental variable. The difficult with instrumental variables is that they must be related to passing traffic safety legislation, but not related to the fatal accidents. While the field should explore such variables in future research, it may be extraordinarily difficult to identify a good instrument.

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[1] General deterrence theory differs from "specific deterrence" because its policies focus on the general population rather than a specific person. The threat of incarceration for committing a crime is a general deterrent policy, while incarcerating an individual is a specific deterrence policy. In the first case a policy-maker's goal is to compel people from engaging in criminal behavior, while in the latter case the goal is to compel that individual from engaging in future crime. Because the policies discussed here are based mainly on general deterrence, this will be the focus of the theoretical discussion.

[2] NHTS, *A Preliminary Assessment of the Impact of Lowering the Illegal BAC Per Se Limit to 0.08 in Five States* (Washington, DC: NHTSA, 1991).

[3] Hingson, R., Heeren, T., & Winter, M., "Lowing state legal blood alcohol limits to .08%: The effect on fatal motor vehicle crashes," *Public Health Reports* 86 (1996): 1297-1299.

[4] Hingson, R., Heeren, T., & Winter, M., "Lower legal blood alcohol limits for young drivers," *Public Health Reports* 109 (1994): 738-745.

[5] General Accounting Office, *Highway safety: Effectiveness of state .08 blood alcohol laws.* (Washington, DC: United States General Accounting Office, 1999).

[6] Zador, P. L., Lund, A. K., Fields, M., & Weinberg, K., "Fatal crash involvement and laws against alcohol-impaired driving," *Journal of Public Health Policy* (1989): 467-485.

[7] Dee, T. S., "State drinking policies, teen drinking and traffic fatalities," *Journal of Public Economics*, 72 (1999): 289-315.
[8] Mast, B. D., Benson, B. L., & Rasmussen, D., W., "Beer taxation and alcohol-related traffic fatalities," *Southern Economic Journal*, 66 (1999): 214-248.
[9] NHTSA, The relationship of alcohol safety laws to drinking and drivers in fatal crashes. (Washington, DC: Department of Transportation, 1999).
[10] Eisenberg, D., "Evaluating the effectiveness of policies related to drunk driving," *Journal of Policy Analysis and Management*, 22 (2003): 249-274.
[11] Mast, et al, 214-248.
[12] Zodar, et al. (1989), 467-485; Mast et al, 214-248.
[13] NHTSA (1999); Dee (1999), 289-315; Eisenberg, 249-274.
[14] Eisenberg, 249-274.
[15] Mast, et al, 214-248.
[16] Eisenberg, 249-274.
[17] Ruhm, C. J., "Economic conditions and alcohol problems," *Journal of Health Economics 14* (1995): 583-603.; Kenkel, D. S., "Drinking, driving, and deterrence: The effectiveness and social costs of alternative policies," *Journal of Law and Economics*, 36 (1993): 877-913.; Dee (2001).; Eisenberg, 249-274.
[18] Dee (2001).; Eisenberg, 249-274.
[19] Zador, et al. (1989).
[20] Kenkel, 877-913.
[21] Mast et al., 214-248.; Eisenberg, 249-274.
[22] Sloan, F. A., Reilly, B. A., & Schenzler, C., "Effects of prices, civil and criminal sanctions, and law enforcement on alcohol-related mortality," *Journal of Studies on Alcohol*, 55 (1994): 454-465.; Sloan, F. A., Reilly, B. A., & Schenzler, C., "Effects of tort liability and insurance on heavy drinking and drinking and driving," *Journal of Law and Economics*, 38 (1995).; Mast et al., 214-248; Eisenberg, 249-274.
[23] Ruhm, 877-913.
[24] Mast, et al., 214-248; and Dee (1999), 289-315.
[25] Eisenberg, 249-274.
[26] Klien, T., *A method for estimating posterior BAC distributions for persons involved in fatal traffic accidents* (Washington, DC: NHTSA, 1989).
[27] See for example, Mast et al., 214-248; Dee (1999), 289-315 and Eisenberg, 249-274.
[28] Eisenberg, 249-274.
[29] See for example, Dee (1999), 289-315.
[30] Dee (1999), 289-315; Eisenberg, 249-274.
[31] See for example, Dee (1999), 289-315 and Hingson et al. (1994).
[32] Zador, P. L., "Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex," *Journal of Studies on Alcohol* 52 (1991): 302-310.; Zador, P. L., Krawchuk, S. A., & Voas, R. B., "Alcohol-related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: An update using 1996 data," *Journal of Studies on Alcohol*, 61 (2000): 387-395.
[33] Eisenberg, 249-274.
[34] *Ibid,* 249-274.
[35] Zador.; Zador, et al. (2000), 387-395.
[36] See for example, Eisenberg, 249-274.
[37] Mast et al, 214-248.
[38] *Ibid,* 214-248.
[39] Caulkins and Zalapator.
[40] Eisenberg, 249-274.
[41] Mast, et al, 214-248.
[42] Eisenberg, 249-274.