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DOES GOVERNMENT REGULATION OF ALCOHOL HAVE AN EFFECT ON ALCOHOL-RELATED TRAFFIC FATALITIES—A PANEL ANALYSIS ON THE UNITED STATES BETWEEN 1982 AND 2002

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Submitted to the Economics Faculty
in partial fulfillment of the requirements for the degree of
Bachelor of Science in Business Administration

December, 2009

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The 21st amendment gave states the power to regulate, sell, and distribute alcohol. To date, nineteen states have opted for control. Previous research has examined the effects of state regulation on alcohol-related traffic fatalities, but has ignored the variations in the degree of regulation across states. This paper presents a panel study of 50 states from 1982 to 2002 that measures the impact of the degree of alcohol control on the incidence of alcohol-related traffic fatalities.

Utilizing a fixed-effects vector decomposition with panel-corrected standard errors procedure, the results suggest that as a whole, control states experience significantly more alcohol-related traffic fatalities compared to states which do not regulate alcohol. Aside from states which regulate alcohol at the wholesale level, the varying degree of control does not appear to have a significant effect on those who are 21 or older. More daunting, though, are the estimates which suggest that any form of government control on alcohol results in an increase in alcohol-related traffic fatalities for those who are under the age of 21.

JEL classifications: I18, K32, R40, R41

Key words: alcohol, regulation, policy, traffic fatalities, United States

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I. Introduction

According to the National Highway Traffic Safety Administration (NHTSA), an individual has a 30 percent chance of being involved in an alcohol-related traffic fatality in their lifetime (NHTSA, 2001a). Between 1982 and 2002, alcohol-related traffic fatalities decreased by approximately 33 percent in the United States. During that same time period, numerous alcohol-control policies were implemented with the specific intent of decreasing such fatalities. Research has shown that alcohol-control policies have had a significant effect on alcohol-related traffic fatalities. It is reasonable to assume that states regulating alcohol sales at both the retail and wholesale levels would have significantly different effects on fatalities compared to states regulating only at the wholesale level. Research on this topic has been virtually ignored.

In my research, I conduct a panel study of 50 states measuring the impact of the degree of alcohol control on the incidence of alcohol-related traffic fatalities from 1982 to 2002. The results suggest that states that regulate alcohol in any form experience significantly more alcohol-related traffic fatalities compared to states that do not. Furthermore, the estimates suggest that while wholesale controls have no effect, varying degrees of retail control have a significant effect on fatalities involving legal aged individuals. The results also suggest that any degree of regulation significantly increases alcohol-related traffic fatalities for those who are underage.

II. Literature Review

The 21st Amendment granted power to the individual states to regulate, sell, and distribute alcohol. To date, nineteen states have opted to regulate. States may regulate alcohol as a means of revenue generation, to discourage excessive consumption (Room, 1987), or as a reflection of the state's cultural values (Holder, 1993).

Analyzing the pre- and post-privatization of Iowa's alcohol retail system, Macdonald (1986) investigates whether increased alcohol availability leads to increased alcohol consumption. He finds that privatization results in increased consumption of wine, but no change in consumption of beer or spirits. Fitzgerald and Mulford (1988) study Iowa's privatization of alcohol sales pre- and post-privatization using both state survey data as well as monthly alcohol sales between July 1983 and August 1987. Fitzgerald and Mulford claim that the increase in wine consumption is due to two events. First, in the months following Iowa's decision to privatize, state stores began to liquidate their wine inventory at discount prices, allowing private retailers and consumers to "stock up" on wine. Second, it is likely that "impressive" new wine displays influenced consumers to purchase wine they would not have ordinarily purchased had it been sold in a state run store—Fitzgerald and Mulford state, though, that it is considerably unlikely these consumers became regular wine drinkers as a result of an increase in alcohol availability. Overall, the two studies find that an increase in alcohol use is short-term, and that the alcohol sales *do not* indicate any long-term lasting effect. Fitzgerald and Mulford (1992) find similar results.

Holder and Wagenaar (1990) examine Iowa's privatization of the retail market for alcohol. Although their study is similar to Fitzgerald and Mulford (1988), they claim that their results are more reliable because they account for the biasing effects of non-independent variables. Overall, they find no change in beer consumption, a 13.7 percent decrease in wine consumption, and a 9.5 percent increase in spirits consumption following privatization. In total, Holder and Wagenaar find that Iowa experienced a net increase in alcohol consumption following privatization.

Kenkel (1993) creates a theoretical consumer optimization model where an individual gains utility from two activities: drinking and driving. Kenkel recognizes that a key problem related to this model is that driving becomes both an illegal and dangerous activity if an individual consumes a certain amount of alcohol. Under Kenkel's model, alcohol consumption directly influences alcohol-related traffic fatalities.

The National Alcohol Beverage Control Association (NABCA) classifies states that impose any regulation on alcohol sales, whether at the wholesale or retail level, as "control," and states that impose no regulations as "license." In a study on alcohol-control policies and the driving under the influence (DUI) fatality rate, Kenkel (1993) hypothesized that the DUI fatality rate would be lower in control states. He fits data from the 1985 Health Interview Survey into his theoretical model to examine the relationship between control states and alcohol-related traffic fatalities. His results were inconclusive, providing no relationship between control states and alcohol-related traffic fatalities. Similarly, in a study on alcohol-related traffic fatalities between 1985 and 1995 for Iowa, Ohio, West Virginia, and Pennsylvania, Rees (1997) finds no significant difference in alcohol-related traffic fatalities between control and license states.

Kenkel's (1993) consumer optimization problem is modeled after that of Becker (1969), which assumes that an individual will only commit an offense when the expected utility from the offense outweighs his utility from any other activity. Becker finds that the number of criminal offenses committed by any individual is a function of the probability of conviction, the punishment if convicted, and other personal factors such as a willingness to commit illegal acts. Similar to Becker, Kenkel finds that the discounted expected cost of drunk driving is predominantly a function of the probability of arrest/conviction. Policies which raise the probability of arrest/conviction include a preliminary breath test law and blood alcohol content (BAC) limits.

According to Chaloupka and Saffer (1989), the preliminary breath test law was created to combat the procedural problems associated with convicting a drunk driver. Before enacting this law, the BAC test could only be administered by a trained medical professional. This required police to arrest and transport suspected individuals to a medical testing center for a BAC test. To accelerate this process, officers were granted the ability to administer preliminary breath tests without making an arrest. Chaloupka and Saffer find a statistical decrease in the number of DUI fatalities in states with preliminary breath test laws. Their results also suggest that if every state had this law in 1955, DUI fatalities would have decreased by 2,011. A more recent study by Chaloupka et al. (1993) suggests that if every state had a preliminary breath test law, average annual fatalities would decrease by approximately 3.4 percent; 18 to 20 year-olds would account for 20 percent of this reduction.

In October 2000, the U.S. Congress passed the Department of Transportation's 2001 Appropriations Act which mandated that states consider driving to be illegal if the driver's BAC is at least .08 g/dl (NHTSA, 2001b).[1, 2] Opponents, such as those in the restaurant and hospitality industry, claim this act did not significantly decrease alcohol-related traffic fatalities, and ultimately hurt the industry (Pianin, 1998). Regardless of the supporting evidence, and under

[1] Assuming one drink of alcohol equals 0.54 ounces of alcohol (the approximate amount of alcohol found in one shot of distilled spirits, one can of beer, or one glass of wine), a 170 pound male would need to consume four drinks in one hour to reach the 0.08 g/dl BAC limit. A female weighing 137 pounds would need to consume three drinks in one hour to reach the 0.08 g/dl BAC limit. Naturally, these estimates vary on individual characteristics (Hingson et al., 1999).

[2] To provide an understanding of the differences between BAC levels, an individual who has a BAC level between 0.06 g/dl and 0.10 g/dl experiences impairment in his reflexes, reasoning, and peripheral vision. An individual who has a BAC level between 0.11 g/dl and 0.20 g/dl experiences decreased motor skills and impairment in his reaction time . Any BAC level above 0.20 g/dl can lead to loss of consciousness, memory blackout, or possibly the loss in ability to breathe. (Virginia Tech, 2009)

immense pressure from both lobbyists and pressure groups, the senate reversed the bill. In spite of this, by 2005 every state enacted a 0.08 g/dl BAC law; Delaware was the last state to make the transition (Freeman, 2007).

Research suggests that setting a BAC of .08 g/dl is an effective method for saving lives (Zador et al., 2000; Dee, 2001; and Lund et al., 2007). Lund et al. (2007) suggests that if all drivers had a BAC less than 0.08 g/dl in 2005, approximately 8,916 deaths could have been avoided. Similarly, Dee (2001) finds that 0.08 g/dl BAC laws have reduced traffic fatality rates by approximately 16.5 percent adding that the 0.08 g/dl BAC laws have decreased weekend and weekday fatality rates by 8.6 percent and 5.8 percent, respectively.

In addition to increasing the probability of arrests for individuals who consume alcohol, government policies including the minimum legal drinking age, and primary seat belt laws were enacted. While the former helps protect individuals who are more vulnerable to the effects of alcohol (McCartt et al., 2008), the latter helps protect drivers involved in any automobile accident.

On July 17, 1984, the National Minimum Drinking Age Act was passed requiring states to prohibit the purchase or possession of alcohol by people under the age of 21.[3] Prior to this act, minimum drinking ages varied across states and by alcohol beverage type.[4] Cook and Tauchen (1984) find that states that reduced the minimum drinking age from 21 to 18 experienced an 11.1 percent increase in the traffic fatality rate for 18 to 21 year-olds. Dee and Evans (2001) hypothesized that the movement of the minimum drinking age would only shift driving fatalities

[3] United States Code: Title 23; Chapter 1; Subsection 158

[4] In 1983, the minimum drinking age in Pennsylvania for all beverage types was 21; in Colorado, the minimum drinking age was 18 for beer and 21 for wine and spirits. Cook and Tauchen (1984) agree that this discrepancy in ages is due to the passing of the 26th amendment, an amendment which granted the right for 18 year-olds to vote—it seemed appropriate for 18 year-olds to have the same status as adults given they were able to vote and fight, at the time, in the Vietnam War.

from teens to adult drivers. Instead, they find that the movement significantly decreased alcohol-related traffic fatalities for teen drivers. This is similar to Dee (1990) who finds that changing the minimum drinking age from 18 to 21 substantially reduced abusive teen drinking by 8 percent and teen driving fatalities by 9 percent, which supports the findings of Cook and Tauchen. Summarizing the results, Wagenaar and Toomey (2002), who reviewed 241 empirical analyses on the minimum legal drinking age, conclude that research overall suggests that there is an inverse relationship present between the mandatory legal drinking age and both alcohol consumption and traffic accidents.

Although variations exist, there are two predominant seat belt laws present in the United States: primary and secondary.[5] The primary seat belt law allows an officer to issue a citation when a driver or passenger is sighted not wearing a seat belt, whereas a secondary seat belt law allows an officer to issue a citation only when the driver is pulled over for another traffic violation—e.g. the driver is speeding and is observed not wearing a seat belt. According to Kahane (2000), belt laws are 45 percent and 60 percent effective in reducing traffic fatalities in passenger cars and light trucks, respectively. Chaloupka et al. (1993) and Eisenberg (2003) find similar results. They find a significant decrease in total traffic fatalities, traffic fatalities between midnight and 3:59 A.M., and traffic fatalities in which the driver was intoxicated. Although the research shows an inverse relationship between seat belt laws and traffic fatality rates, Peltzman (1975) suggests that seat belt laws have no effect on the traffic fatality rate; Peltzman's risk compensation theory implies that the gain in wearing a seat belt is offset by the driver's willingness to drive faster and more recklessly. Sobel and Nesbit (2007) and Risa (1994) find similar results.

[5] Persons covered under the primary and secondary seat belt laws vary by state. According to the National Institute for Highway Safety (2009), the primary seat belt law in Alabama requires all fifteen year-olds in the front seat to wear a seat-belt. The primary seat belt law in Alaska requires all sixteen year-olds in any seat to wear a seat-belt.

Economic factors, such as the price of unleaded gasoline, have also been found to influence the traffic fatality rate.[6] As the price of gasoline increases, the cost of driving increases which can lead to drivers driving less which subsequently leads to less traffic fatalities. The reverse can be true implying that as the price of gasoline decreases, the cost of driving decreases which can lead to drivers driving more which subsequently leads to more traffic fatalities. In a review of the literature, Yakovlev and Inden (2009) find evidence which supports the notion that gasoline prices have either a positive or negative effect on traffic fatalities. However research suggests that traffic fatalities significantly decrease given an increase in the price of unleaded gasoline (Sivak, 2009; Grabowski and Morrisey, 2004).

A review of the literature also shows that factors such as the speed limit, vehicle miles traveled, and climate data have significant effects on traffic fatalities. In an empirical study of the United States between 1994 and 2005, Park et al. (2008) find that speed limits, as well as vehicle miles traveled, have a significant effect on traffic related fatalities. Additionally, Yakovlev and Inden (2009) find that rainfall, temperature, and mountainous and coastal terrain have similarly large effects on the traffic fatality rate.

III. Data

The dataset used in this study is a longitudinal panel of 50 U.S. States, excluding the District of Columbia, from 1982 to 2002. Variable summary statistics as well as data sources can be found in Table 1:

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[6] Recent research is primarily focused on the effect of several factors on the traffic fatality rate —the price of gasoline, speed limits, vehicle miles traveled, and climate; with a correlation of 0.885 between the alcohol and traffic fatality rate, it is assumed that a change in either of these factors has a similar effect on both fatality rates.

Table 1: Variable Descriptions and Summary Statistics

Variable Name	*Variable Description*	*Mean (St.Dev.)*
$tfinv_{it}$	Alcohol-involved traffic fatalities per 1,000 people [1]	0.09 (0.04)
$tfinv21_{it}$	Alcohol-involved traffic fatalities per 1,000 people for 15 to 20 year-olds [1]	0.04 (0.02)
$tfimp_{it}$	Alcohol-impaired traffic fatalities per 1,000 people [1]	0.08 (0.03)
$tfimp21_{it}$	Alcohol-impaired traffic fatalities per 1,000 people for 15 to 20 year-olds [1]	0.03 (0.02)
mda_{it}	Minimum legal drinking age for all beverage types [2]	20.69 (0.79)
sb_{it}	Dummy variable for Enforcement/Adoption of a mandatory seat belt law (1=Enforcement/Adoption, 0=otherwise) [2]	0.66 (0.48)
bac_{it}	Dummy variable for Enforcement/Adoption of a 0.08 g/dl BAC limit for drivers (1=Enforcement/Adoption, 0=otherwise) [2]	0.19 (0.39)
$zero_{it}$	Dummy variable for Enforcement/Adoption of a 0.02 g/dl BAC limit for drivers under the age of 21 (1=Enforcement/Adoption, 0=otherwise) [2]	0.37 (0.48)
keg_{it}	Dummy variable for Enforcement/Adoption of a keg registration law (1=Enforcement/Adoption, 0=otherwise) [2]	0.17 (0.38)
pbt_{it}	Dummy variable for Enforcement/Adoption of a preliminary breath test law (1=Enforcement/Adoption, 0=otherwise) [2]	0.51 (0.50)
$open_{it}$	Dummy variable for Enforcement/Adoption of a open container law (1=Enforcement/Adoption, 0=otherwise) [2]	0.49 (0.50)
$dram_{it}$	Dummy variable for Enforcement/Adoption of a dram shop law (1=Enforcement/Adoption, 0=otherwise) [2]	0.83 (0.38)
$nabca_{it}$	Dummy variable for the classification of a state as NABCA Control (1=Enforcement/Adoption, 0=otherwise) [3]	0.37 (0.48)
$full_{it}$	Dummy variable for the classification of a state as Full Control (1=State is classified as Full Control, 0=otherwise) [4]	0.11 (0.31)
mod_{it}	Dummy variable for the classification of a state as Moderate Control (1=State is classified as Moderate Control, 0=otherwise) [4]	0.18 (0.39)
$light_{it}$	Dummy variable for the classification of a state as Light Control (1=State is classified as Light Control, 0=otherwise) [4]	0.07 (0.26)
$nocont_{it}$	Dummy variable for the classification of a state as No Control (1=State is classified as No Control, 0=otherwise) [3]	0.63 (0.48)
$retailbeer_{it}$	Dummy variable if the state regulates the retail sale of beer (1=Regulated, 0=otherwise) [4]	0.07 (0.26)
$retailwine_{it}$	Dummy variable if the state regulates the retail sale of wine (1=Regulated, 0=otherwise) [4]	0.11 (0.31)
$retailspirits_{it}$	Dummy variable if the state regulates the retail sale of spirits (1=Regulated, 0=otherwise) [4]	0.29 (0.46)

(1) (FARS, 2009)—A special thanks goes to Lyn Cianflocco who helped provide additional data which was not readily accessible.

(2) (Ponicki, 2009)—A special thanks goes to Bill Ponicki who helped provide the data quickly.

(3) (NABCA, 2009)

(4) (Pulito and Davies, 2009)

The dependent variable in this study takes two forms: alcohol-impaired and alcohol-involved traffic fatalities per 1,000 persons. The Fatality Analysis Reporting System (FARS) defines an alcohol-impaired traffic fatality as one in which a person (either the occupant of a vehicle or a non-motorist) is killed within 30 days of an automobile accident. To be considered an alcohol-impaired traffic fatality, the automobile accident must include a driver or motorcycle operator who was legally intoxicated with an estimated BAC of at least 0.08 g/dl (ANSI, 1996; NHTSA, 2007). Although this definition is similar to an alcohol-involved traffic fatality, there is one substantial difference; an alcohol-involved traffic fatality can be caused by either the driver of an automobile *or* a non-motorist (i.e. a pedestrian). Additionally, the BAC limit for the person involved must only register at a BAC of 0.01 g/dl (ANSI, 1996; NHTSA, 2007). Lastly, the dependent variables are broken down by two different measures—the first for drivers over the age of 21 (i.e. legal drivers), the other for drivers who are 15-20 years old (i.e. underage drivers).

To successfully measure the effects of government regulation on alcohol-related traffic fatalities, it is important to account for other pertinent alcohol-control policies which have been found to have a statistically significant effect on reducing alcohol-related traffic fatalities. Prior to the National Minimum Legal Drinking Age Act of 1984, drinking ages varied across states and by beverage type. Due to high multicollinearity between the minimum drinking ages for the various forms of alcoholic beverages—beer, wine, and spirits—I create a variable which reflects the youngest age one can purchase and consume alcohol. The mandatory seat belt variable reflects the year in which a mandatory seat belt law, either primary *or* secondary, was adopted. Due to high multicollinearity present between primary and secondary seat belt laws (Yakovlev and Inden, 2009), this new variable allows for the total effects of seat belt laws to be measured. The BAC limit variable reflects the year in which a state enacted a law making it illegal for an automobile operator to drive with a BAC greater than or equal to 0.08 g/dl. The zero tolerance law is similar to the BAC limit except it pertains to individuals under the age of 21. This zero tolerance law represents the year in which a state enacted a BAC limit no higher than 0.02 g/dl for underage drivers.[7]

The remaining alcohol-control policies are dummy variables which reflect the year the law was enacted by the state. A keg registration law mandates that when a keg is purchased, the individual purchasing it must register the keg's serial number with personal identification information including name, address, and a driver's license number (NIAAA, 2009). A preliminary breath test law allows police officers to administer a BAC test if the driver is suspected of being intoxicated. An open container law prohibits alcohol from being readily accessible by either the driver or passenger of a moving vehicle. According to NHTSA, the open container law pertains to any receptacle containing alcohol that is either open or has a broken seal or in which the contents have been partially removed.[8] The last alcohol-control policy used in this study is the dram shop law. This law creates liability for any establishment that serves alcohol to an obviously intoxicated person who is subsequently involved in an alcohol-related traffic fatality (MADD, 2009).

To account for the various types of control imposed by the control states, I utilize a classification system created by Pulito and Davies (2009). In their research, they separate "control" and "license" states into four classifications—full, moderate, light, and no control. Refer to Table 2 for the definitions of each classification:

[7] It is important to note that this alcohol-control policy reflects the year the state enacted a *maximum* BAC limit for all drivers under the age of 21. For instance, while Texas mandates a BAC limit of 0.00 g/dl for underage drivers, Pennsylvania instead mandates a BAC limit of 0.02 g/dl (NHTSA, 1997).
[8] United States Code: Title 23; Chapter 1; Subsection 154

Table 2: Regulation Classifications

NABCA Control *Retail or Wholesale Controlled*	Alcohol sales are controlled at either the wholesale or retail levels. This is NABCA's definition of "control".
Full Control *Retail and Wholesale Controlled*	Sales of at least two types of alcohol (beer, wine, and liquor) are controlled at the retail level, and a sale of at least one type of alcohol is controlled at the wholesale levels.
Moderate Control *Partial Retail and Wholesale Controlled*	Sales of only one type of alcohol (beer, wine, or liquor) are controlled at the retail level, and the sale of at least one type of alcohol is controlled at the wholesale level.[9]
Light Control *Wholesale Controlled*	No sales are controlled at the retail level, and the sale of at least one type of alcohol is controlled at the wholesale level.
License *No Control*	Alcohol sales are not controlled.

Figure 1 illustrates the states that are considered "control" states by the NABCA. Any state not depicted is a "license" state (i.e. no regulation). The NABCA classifies Maryland as a control state even though Montgomery County is the only county to regulate alcohol. Due to the inability to differentiate between the sale of alcohol for Montgomery County and Maryland, Maryland is dropped from the research. In addition to the various forms of control, I introduce three additional variables which reflect the various forms of retail regulation imposed by the control states. The variables *retailbeer*, *retailwine*, and *retailspirits* are dummy variables which reflect whether or not a state regulates the retail sale of beer, wine, and spirits respectively. Figure 2 and Figure 3 illustrate the several forms of control (i.e. full, moderate, and light) as well as the several retail classifications (i.e. the regulation of the retail sale of beer, wine, and spirits).[10, 11]

[9] At the retail level, Idaho regulates all beverages that exceed 16 percent alcohol, and Ohio regulates all beverages that exceed 21 percent alcohol. Wine and Spirits have an average alcohol content of 12 percent and 40 percent, respectively (U.S. Department of Health and Human Services, 2005). Based on these content levels, Ohio and Idaho have been classified as moderate control.
[10] It is important to note that these classifications are as of 2002. For example, in 1987 and 1990, Iowa and West Virginia privatized, respectively. Under the classifications noted in Table 2, Iowa and West Virginia moved from full to light control the year they privatized.
[11] Although the classifications were provided by Pulito and Davies (2009), the following changes have been made: 1) The full, moderate, and light classifications now include any state that controls the wholesale of at least one type of alcohol 2) A state is classified as full control if the state regulates at least two alcohol beverage types.

Figure 1: NABCA Control by State in 2002

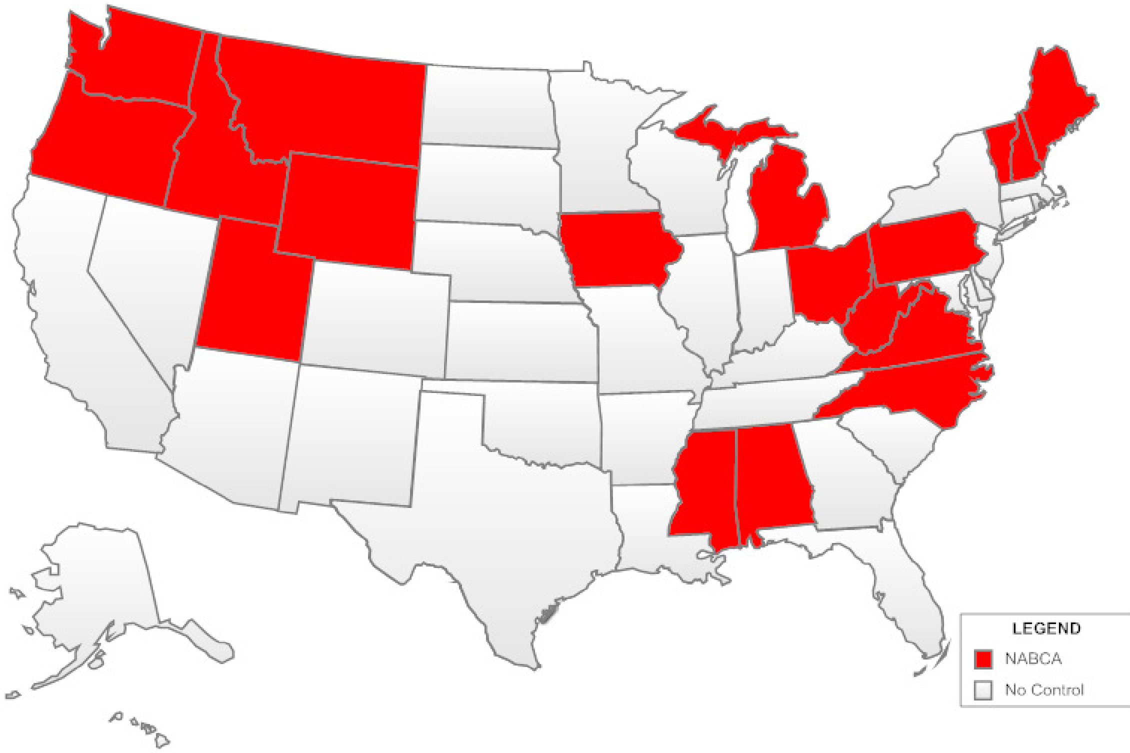


Figure 2: Classification of Control by State in 2002

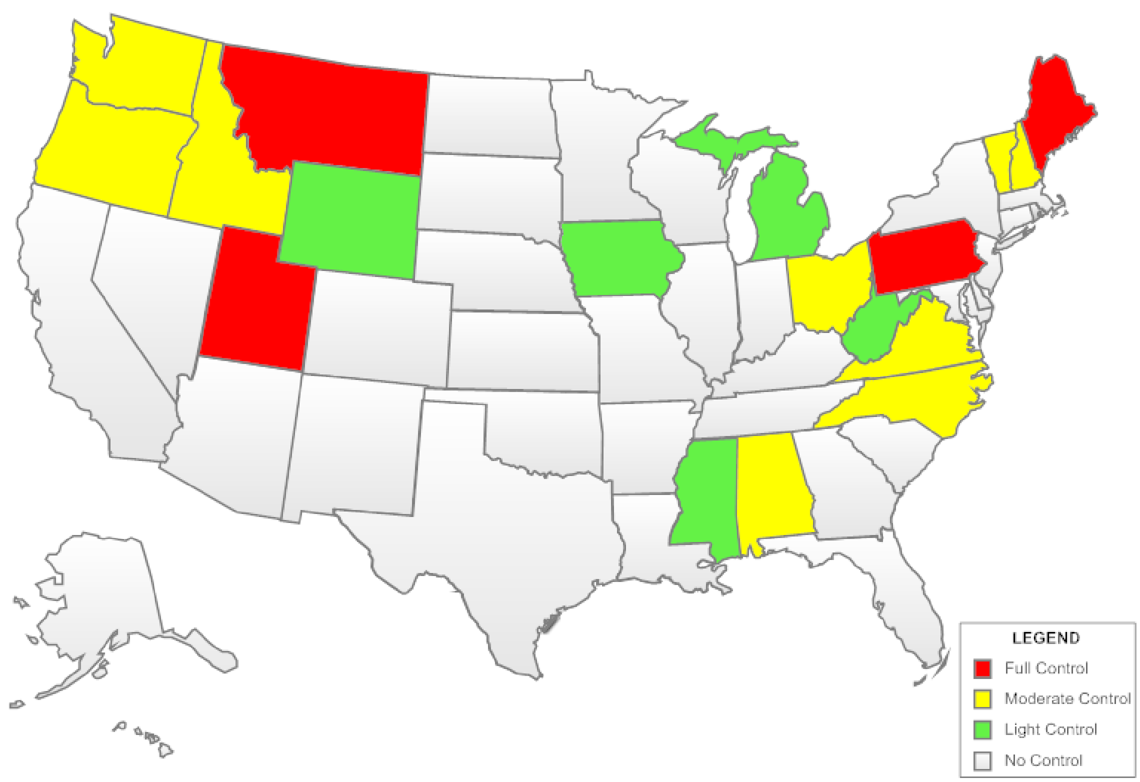
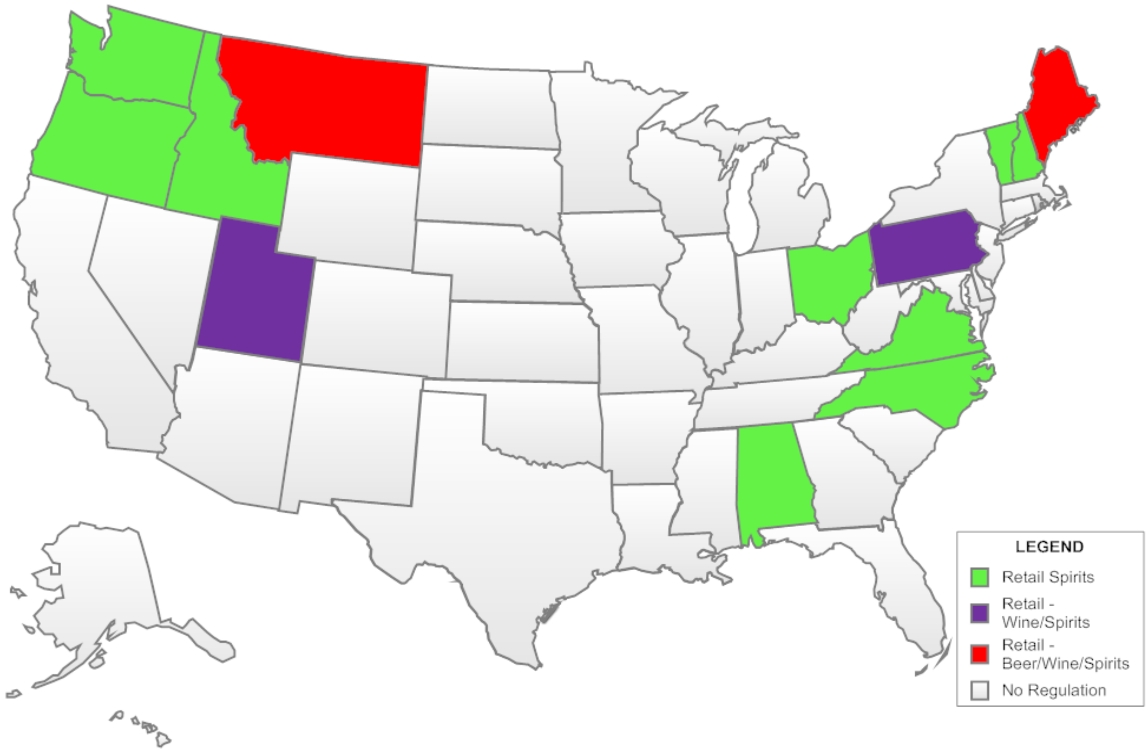


Figure 3: Retail Regulation by State in 2002



IV. Empirical Model

A. Statistical Anomalies

In the presence of unobserved heterogeneity which can cause ordinary least squares (OLS) estimates to be biased and inconsistent, a commonly used econometric technique is to include a fixed-effect estimator.[12] However, a problem arises when the regressors are either time-invariant (i.e. the NABCA classification), or rarely-changing (i.e. full, moderate, and light control). The fixed effect estimator will absorb these variables estimates (Yakovlev and Inden, 2009). In a recently developed procedure created by Plümper and Troger (2007), a method known as a Fixed-Effect Vector Decomposition (FEVD) is used allowing for a fixed-effect

[12] The Hausman and Breusch-Pagan random effects test supports the choice for a fixed effects model.

estimator given time-invariant and rarely changing variables.[13] In numerous Monte Carlo simulations, the FEVD outperforms OLS, random effects, and the Hausman-Taylor estimators if the time-invariant/rarely changing variables are correlated with the fixed effects.

In addition to correcting for unobserved heterogeneity, the models used in this analysis exhibit signs of groupwise heteroskedasticity, contemporaneous correlation, serial/auto correlation, and non-stationarity. To correct for the groupwise heteroskedasticity and contemporaneous correlation, the FEVD model is run with panel-corrected standard errors (Beck and Katz, 1995). The auto-correlation is corrected by an AR(1) process and the non-stationarity is corrected through cointegration between the dependent and independent variables. Refer to Appendix 1A for the non-stationarity on each of the model's residuals.

B. Government Regulation on Alcohol-Related Traffic Fatalities

Building on previously cited literature, I propose the following four models which analyze the overall effects of government regulation on alcohol-involved traffic fatalities:

$$tfinv_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \gamma C_{it} + h_i + \varepsilon_{it} \qquad (1)$$

$$tfinv21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \gamma C_{it} + h_i + \varepsilon_{it} \qquad (2)$$

$$tfimp_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \gamma C_{it} + h_i + \varepsilon_{it} \qquad (3)$$

$$tfimp21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \gamma C_{it} + h_i + \varepsilon_{it} \qquad (4)$$

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[13] Comparing the regression results generated by the FEVD procedure to an OLS procedure with panel-corrected standard errors, it appears that the OLS procedure provides lower t-stats. However, several estimates for the rarely changing/time-invariant variables become insignificant when the OLS procedure is used; this further cements the use of Plümper and Troger's (2007) procedure. Lastly, the r-squared values for my research are not unreasonable compared to Young and Likens (2000) who found an r-squared no lower than 0.96 in their similar research.

Where $tfinv_{it}$ is the alcohol-involved traffic fatality rate, $tfinv21_{it}$ is the underage alcohol-involved traffic fatality rate, $tfimp_{it}$ is the alcohol-impaired traffic fatality rate and $tfimp21_{it}$ is the underage alcohol-impaired traffic fatality rate, X_{it} is a vector of regressors, C_{it} is a dummy variable if the state is classified as a control state by the NABCA, h_i is the fixed-effect estimator, and ε_{it} is the disturbance; the subscripts $i = 1,\ldots,49$ and $t = 1982,\ldots,2002$ represent the states and years, respectively. The regressors X_{it} include the minimum legal drinking age, mandatory seat belt law, and the following dummy variables: the 0.08 g/dl BAC limit, zero tolerance law, keg registration law, preliminary breath test, open container law, and the dram shop law. Through the remainder of the paper, the vector of regressors, X_{it}, will be referred to as the alcohol-control policies and will always contain the same variables as previously mentioned. Throughout the interpretations, the results will refer to alcohol-related traffic fatalities. Such reference refers to traffic fatalities as a whole and not necessarily alcohol-involved or alcohol-impaired fatalities specifically.

The models in equations (1), (2), (3), and (4) are estimated via a fixed-effect vector decomposition with panel-corrected standard errors. The results are shown in Table 3.

Table 3: Alcohol-Involved/Impaired Traffic Fatalities (NABCA Classification)

	Legal Age Alcohol-*Involved* Traffic Fatalities	Underage Alcohol-*Involved* Traffic Fatalities	Legal Age Alcohol-*Impaired* Traffic Fatalities	Underage Alcohol-*Impaired* Traffic Fatalities
Minimum Drinking Age	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Mandatory Seat Belt	-0.012***	-0.009***	-0.011***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
BAC Limit	-0.008***	-0.004***	-0.007***	-0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
Zero Tolerance	-0.010***	-0.008***	-0.009***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Keg Registration	-0.008***	-0.008***	-0.007***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.001)
Preliminary Breath Test	-0.006***	-0.002*	-0.006***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Open Container	-0.015***	-0.008***	-0.013***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Dram Shop	-0.014***	-0.009***	-0.013***	-0.007***
	(0.002)	(0.001)	(0.002)	(0.001)
NABCA	0.005***	0.005***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.209***	0.151***	0.190***	0.124***
	(0.020)	(0.016)	(0.017)	(0.013)
Observations	1029	1029	1029	1029
R-Squared	0.863	0.761	0.875	0.759

Dependent variable: Alcohol-involved/impaired traffic fatalities and underage alcohol-involved/impaired traffic fatalities per 1,000 people. Significant levels: *** at 1%, ** at 5%, and * at 10%. Panel-corrected standard errors are reported in parentheses. Autocorrelation Correction: AR(1)

All of the alcohol-control policies significantly decrease the alcohol-related traffic fatality rate. Interestingly, the NABCA classification suggests that states regulating alcohol have significantly more traffic fatalities than those that do not. One possible explanation can be attributed to what is known as the "convenience effect" which suggests that when the retail market of alcohol is regulated, people are inconvenienced due to restricted hours, reduced retail locations, and reduced attention to customers' needs (Pulito and Davies, 2009). The inconvenience can lead consumers to purchase either more alcohol or a stronger type of alcohol in order to reduce the volume of alcohol to be transported.

C. The Effects of Retail Regulation on Alcohol-Related Traffic Fatalities

While the NABCA classifies a state as a control state regardless of the form of regulation it imposes, it is reasonable to assume that there are significantly different effects given the various forms of retail regulation imposed. The following four models look to examine these effects:

$$tfinv_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j R_{it}^{j} + h_i + \varepsilon_{it} \quad (5)$$

$$tfinv21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j R_{it}^{j} + h_i + \varepsilon_{it} \quad (6)$$

$$tfimp_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j R_{it}^{j} + h_i + \varepsilon_{it} \quad (7)$$

$$tfimp21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j R_{it}^{j} + h_i + \varepsilon_{it} \quad (8)$$

Where $tfinv_{it}$ is alcohol-involved traffic fatality rate, $tfinv21_{it}$ is the underage alcohol-involved traffic fatality rate, $tfimp_{it}$ is alcohol-impaired traffic fatality rate and $tfimp21_{it}$ is the underage alcohol-impaired traffic fatality rate, X_{it} are the alcohol-control policies, R_{it} is a dummy variable if the state regulates the retail sale of beer, wine, and/or spirits, respectively, h_i is the fixed-effect estimator, and ε_{it} is the disturbance; the subscripts $i = 1,\ldots,49$ and $t = 1982,\ldots, 2002$ represent the states and years, respectively. The models in equations (5), (6), (7), (8) are estimated via a fixed-effect vector decomposition with panel-corrected standard errors. The results are shown in Table 4.

Table 4: Alcohol-Involved/Impaired Traffic Fatalities *(State Retail Control)*

	Legal Age Alcohol-*Involved* Traffic Fatalities	Underage Alcohol-*Involved* Traffic Fatalities	Legal Age Alcohol-*Impaired* Traffic Fatalities	Underage Alcohol-*Impaired* Traffic Fatalities
Minimum Drinking Age	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Mandatory Seat Belt	-0.012***	-0.009***	-0.011***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.001)
BAC Limit	-0.008***	-0.004***	-0.006***	-0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
Zero Tolerance	-0.010***	-0.008***	-0.009***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Keg Registration	-0.008***	-0.008***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.001)
Preliminary Breath Test	-0.006***	-0.002**	-0.006***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Open Container	-0.015***	-0.008***	-0.013***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Dram Shop	-0.014***	-0.009***	-0.013***	-0.007***
	(0.002)	(0.001)	(0.002)	(0.001)
Retail Beer	-0.028***	-0.013***	-0.026***	-0.013***
	(0.005)	(0.003)	(0.004)	(0.003)
Retail Wine	0.013**	0.008***	0.014***	0.009***
	(0.006)	(0.003)	(0.004)	(0.003)
Retail Spirits	0.001	0.004***	-0.001	0.002**
	(0.002)	(0.001)	(0.002)	(0.001)
Constant	0.211***	0.151***	0.193***	0.125***
	(0.020)	(0.016)	(0.017)	(0.013)
Observations	1029	1029	1029	1029
R-Squared	0.863	0.759	0.875	0.759

Dependent variable: Alcohol-involved/impaired traffic fatalities and underage alcohol-involved/impaired traffic fatalities per 1,000 people. Significant levels: *** at 1%, ** at 5%, and * at 10%. Panel-corrected standard errors are reported in parentheses. Autocorrelation Correction: AR(1)

The estimates for the alcohol-control policies agree with previously cited literature. As expected, estimates for legal and underage alcohol-related traffic fatalities suggest that states regulating beer have significantly fewer traffic fatalities than states without such regulations. Compared to wine and spirits, beer has a disproportionate effect on alcohol-related traffic fatalities (Cohen 2003). Regulating the sale of beer, the most commonly sold alcoholic beverage, and removing it from locations such as gas stations, convenience stores, and grocery stores, makes purchasing beer more inconvenient. There are currently no states that solely regulate the retail sale of beer. Any state regulating beer also regulates wine and spirits. The estimate for retail beer regulation supports the "convenience effect" stated by Pulito and Davies (2009). State regulation makes purchasing alcohol more inconvenient. As a result, individuals purchase more alcohol, presumably wine according to the estimates. It is interesting to note that the retail regulation of spirits has had no significant effect on traffic fatalities.

Similar to estimates for individuals over age 21, traffic fatalities for those under 21 significantly decrease when a state regulates the sale of beer. The estimates for regulation of wine and spirits, however, indicate a significant increase in fatalities as a result of regulation. Underage individuals cannot legally purchase alcohol and must rely on those of legal age to make the purchase. Because it is less convenient to purchase alcohol in a regulated state, individuals purchasing alcohol for those who are underage may purchase more in a single trip in order to decrease the number of trips made. As a result, underage drinkers potentially have more alcohol available which could lead to both increased consumption and alcohol-related traffic fatalities.

D. Varying Degrees of Government Regulation on Alcohol-Related Traffic Fatalities

In the last model of my research, I examine the various forms of government regulation (i.e. full, moderate, and light) on alcohol-related traffic fatalities. The following four models allow for a richer analysis of alcohol-related traffic fatalities by segmenting the states based on the amount of regulation they impose:

$$tfinv_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j C_{it}^{j} + h_i + \varepsilon_{it} \tag{9}$$

$$tfinv21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j C_{it}^{j} + h_i + \varepsilon_{it} \tag{10}$$

$$tfimp_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j C_{it}^{j} + h_i + \varepsilon_{it} \tag{11}$$

$$tfimp21_{it} = \alpha + \sum_{j=1}^{8} \beta_j X_{it}^{j} + \sum_{j=1}^{3} \gamma_j C_{it}^{j} + h_i + \varepsilon_{it} \tag{12}$$

Where $tfinv_{it}$ is alcohol-involved traffic fatality rate, $tfinv21_{it}$ is the underage alcohol-involved traffic fatality rate, $tfimp_{it}$ is alcohol-impaired traffic fatality rate and $tfimp21_{it}$ is the underage alcohol-impaired traffic fatality rate, X_{it} are the alcohol-control policies, C_{it} is a dummy variable if the state is classified as either a full, moderate, or light control state, h_i is the fixed-effect estimator, and ε_{it} is the disturbance; the subscripts i = 1,…, 49 and t = 1982,…, 2002 represent the states and year, respectively. The models in equations (5), (6), (7), (8) are estimated via a fixed-effect vector decomposition with panel-corrected standard errors. The results are shown in Table 5.

Table 5: Alcohol-Involved/Impaired Traffic Fatalities *(State Classification—Full, Moderate, Light)*

	Legal Age Alcohol-*Involved* Traffic Fatalities	Underage Alcohol-*Involved* Traffic Fatalities	Legal Age Alcohol-Impaired Traffic Fatalities	Underage Alcohol-Impaired Traffic Fatalities
Minimum Drinking Age	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Mandatory Seat Belt	-0.012***	-0.009***	-0.011***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
BAC Limit	-0.008***	-0.004***	-0.007***	-0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
Zero Tolerance	-0.010***	-0.008***	-0.009***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Keg Registration	-0.008***	-0.008***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.001)
Preliminary Breath Test	-0.006***	-0.002**	-0.006***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Open Container	-0.015***	-0.008***	-0.013***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Dram Shop	-0.014***	-0.009***	-0.013***	-0.007***
	(0.002)	(0.001)	(0.002)	(0.001)
Full Control	-0.002	0.004***	-0.001	0.003**
	(0.003)	(0.001)	(0.002)	(0.001)
Moderate Control	0.003*	0.005***	0.002	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)
Light Control	0.022***	0.007***	0.020***	0.006***
	(0.002)	(0.002)	(0.003)	(0.002)
Constant	0.209***	0.151***	0.191***	0.124***
	(0.012)	(0.016)	(0.017)	(0.013)
Observations	1029	1029	1029	1029
R-Squared	0.863	0.759	0.875	0.759

Dependent variable: Alcohol-involved/impaired traffic fatalities and underage alcohol-involved/impaired traffic fatalities per 1,000 people. Significant levels: *** at 1%, ** at 5%, and * at 10%. Panel-corrected standard errors are reported in parentheses. Autocorrelation Correction: AR(1)

Aside from the alcohol-control policies matching previous research, the various classifications provide interesting insight. For individuals over 21, the results suggest that states that have full and moderate control have no significant relationship with alcohol-related traffic fatalities. States that impose light control, however, experience significantly more alcohol-related traffic fatalities compared to states with no control. For underage individuals, the results suggest that states with any of the three forms of government regulation have significantly more traffic fatalities than states with no control.

One could interpret the results as suggesting that the degree of government regulation does not have as significant an impact on legal individuals as it does on those who are underage. Perhaps alcohol regulation provides a bigger inconvenience to those who are underage. The results suggest that all forms of government regulation lead to an increase in alcohol-related traffic fatalities for those under 21.

V. Future Research

Future researchers should consider expanding the model by examining the effects of government regulation in countries other than the United States. Such research could include additional variables such as how cultural differences influence alcohol consumption. For instance, Italy allows individuals to consume alcohol at age sixteen and only one percent of the country's traffic-fatalities involved the use of alcohol in 1995 (NHTSA, 2000).

VI. Conclusion

This study utilizes a longitudinal panel of 50 states, excluding the District of Columbia, from 1982 to 2002. Room (1987) claims that states regulate alcohol to discourage excessive consumption by limiting its availability. Controlling for numerous alcohol-control policies, the results suggest that although the government's intention is to decrease traffic fatalities through regulation, this actually leads to an increase in alcohol-related traffic fatalities in the under 21 age group. Davies and Pulito (2009) postulate that such an increase can be attributed to the “convenience effect” which can potentially lead consumers to either purchase more alcohol in a single trip, or purchase alcoholic beverages with a stronger alcohol-content to decrease the volume to be transported.

Overall, the results suggest that states classified by the NABCA as control states have significantly more alcohol-related traffic fatalities than states which maintain no government control. In addition, the results suggest that for drivers over 21, state regulation of beer has significantly decreased alcohol-related traffic fatalities. State regulation on wine however has significantly increased alcohol-related traffic fatalities in this same group. Finally, the results suggest that states classified as full or moderate control have had no significant effect on the fatality rate of individuals over 21; light control states however have shown a significant increase.

Regarding underage individuals, the results are somewhat troubling. While regulation of beer has significantly decreased alcohol-related traffic fatalities, there has been a significant increase in states controlling the retail market of both wine and spirits. Furthermore, the results suggest that any form of government regulation—i.e. full, moderate, or light—leads to a significant increase in alcohol-related traffic fatalities.

The research suggests that government regulation is not an effective method of decreasing alcohol related traffic fatalities and provides additional research data for governments to consider when evaluating this issue.

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Appendix: Non-Stationarity Tests

Table 6: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Involved Traffic Fatalities (NABCA Classification) (Model 1 and 2)

	Legal Age Alcohol-Involved Traffic Fatalities			Underage Alcohol-Involved Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-8.470***	255.212***	279.644***	-11.456***	314.001***	344.483***
Trend and Intercept	-7.648***	227.000***	239.494***	-9.829***	273.092***	285.035***
None	Not Applicable	457.769***	471.967***	Not Applicable	547.792***	591.915***

***indicates the variable is significant at the 0.01 level.

Table 7: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Impaired Traffic Fatalities (NABCA Classification) (Model 3 and 4)

	Legal Age Alcohol-Impaired Traffic Fatalities			Underage Alcohol-Impaired Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-9.300***	267.123***	290.289***	-11.572***	316.395***	405.878***
Trend and Intercept	-6.970***	211.994***	238.764***	-8.365***	235.874***	357.964***
None	Not Applicable	463.793***	474.151***	Not Applicable	553.003***	617.605***

***indicates the variable is significant at the 0.01 level.

Appendix: Non-Stationarity Tests (Continued)

Table 8: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Involved Traffic Fatalities (State Retail Control) (Model 5 and 6)

	Legal Age Alcohol-Involved Traffic Fatalities			Underage Alcohol-Involved Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-8.670***	253.915***	278.315***	-11.474***	314.430***	344.970***
Trend and Intercept	-7.650***	226.723***	240.139***	-9.859***	273.711***	285.483***
None	Not Applicable	446.233***	468.942***	Not Applicable	547.618***	591.064***

***indicates the variable is significant at the 0.01 level.

Table 9: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Impaired Traffic Fatalities (State Retail Control) (Model 7 and 8)

	Legal Age Alcohol-Impaired Traffic Fatalities			Underage Alcohol-Impaired Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-9.342***	268.001***	287.804***	-11.368***	311.950***	406.159***
Trend and Intercept	-7.204***	217.976***	239.462***	-8.494***	238.394***	370.950***
None	Not Applicable	487.562***	476.367***	Not Applicable	553.019***	615.970***

***indicates the variable is significant at the 0.01 level.

Appendix: Non-Stationarity Tests (Continued)

Table 10: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Involved Traffic Fatalities (State Classification—Full, Moderate, Light) (Model 9 and 10)

	Legal Age Alcohol-Involved Traffic Fatalities			Underage Alcohol-Involved Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-8.691***	254.280***	278.040***	-11.462***	314.130***	344.502***
Trend and Intercept	-7.652***	226.844***	239.472***	-9.837***	273.193***	285.099***
None	Not Applicable	463.849***	469.658***	Not Applicable	548.907***	592.137***

***indicates the variable is significant at the 0.01 level.

Table 11: Non-Stationarity Results (Null Hypothesis: Common Unit Root Process Exists)
Alcohol-Impaired Traffic Fatalities (State Classification—Full, Moderate, Light) (Model 11 and 12)

	Legal Age Alcohol-Impaired Traffic Fatalities			Underage Alcohol-Impaired Traffic Fatalities		
Test Form	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**	**Im, Pesaran, and Shing W-Stat**	**ADF – Fisher Chi-Square**	**PP – Fisher Chi-Square**
Intercept Only	-9.277***	266.609***	291.215***	-11.355***	311.532***	406.876***
Trend and Intercept	-7.244***	217.802***	239.377***	-8.382***	236.126***	360.229***
None	Not Applicable	463.436***	470.276***	Not Applicable	552.934***	616.803***

***indicates the variable is significant at the 0.01 level.