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Drunk Driving in the United States: An Examination of Informal and Formal Factors to Explain Variation in DUI Enforcement across U.S. Counties

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Abstract: *This research aims to understand how informal non-legal factors, such as normative climates, and formal legal factors, such as open-container laws, seat-belt laws, and police force strength are related to variation in drunk driving (DUI) enforcement across U.S. counties. In particular, this study focuses on explaining whether differences in the macro-level normative climates toward drinking (i.e., anti-drinking normative climates and pro-drinking normative climates) are related to levels of DUI enforcement by police. It is unclear whether informal factors exert effects on DUI enforcement, independent of formal legal factors. This study takes a population-based approach and uses cross-sectional information (1999-2001) compiled from a variety of official agencies that disseminate county-level data. Results from Exploratory Spatial Data Analysis (ESDA) and Spatial Regression Analyses suggest that areas with anti-drinking normative climates are associated with higher levels of DUI enforcement. Conversely, areas with pro-drinking normative climates tend to be associated with lower levels of DUI enforcement. Overall, these findings suggest that normative climates toward drinking account for some of the variation in rates of DUI enforcement, independent of formal legal factors. Limitations and implications for DUI control and future research are discussed.*

Keywords: arrest rates, counties, drunk driving, DUI, normative climates

INTRODUCTION

Effective control of drunk driving (DUI) is a priority of interest groups, public health officials, policy makers, and law enforcement agencies in the United States. Efforts to control DUI generally rely on a deterrence model—that lower rates of DUI are associated with increased formal sanctions and increased certainty of arrest (Jacobs 1989; Ross 1992). However, macro-level informal factors, which are not part of the formal legal system, may also be related to levels of DUI enforcement in an area. Drunk driving varies considerably across the United States, but the factors that account for differences in DUI enforcement by police remain unclear. While a large body of empirical research has examined how formal legal factors, such as DUI laws, are related to variation in DUI behavior (e.g., DeJong and Hingson 1998), much less research has focused on understanding how informal norms may account for variation in DUI enforcement across geographical areas.

Informal social norms are fundamental to social organization and human behavior; norms provide informal rules about how people "ought" to behave (Homans 1961). The informal rules, values, and beliefs regarding alcohol consumption are different among groups and across areas of the U.S. In some areas, drinking alcohol is acceptable and normative behavior, whereas in other areas, there is a strong normative climate that severely regulates acceptable

drinking. While it is well established that community political and social climates influence police practice (Wilson 1968) and departmental contexts shape police behavior (Mastrofski, Ritti, and Hoffmaster 1987), it is unclear whether police enforcement of DUI varies in relation to macro-level normative climates toward drinking.

In contrast to informal factors, the formal legal system features a number of laws, policies, ordinances, and police practices to control drunk driving. However, these laws are not applied equally across areas of the U.S. and they are not equally enforced. For example, several states have laws permitting roadside sobriety checkpoints, but even though checkpoints are legal, there is within-state variation in the frequency in which they are conducted by police. Although DUI-control laws in some areas are associated with lower rates of drunk driving, the extent to which area-wide informal norms exerts effects independent of formal laws has not been established in previous research.

The overarching goal of this research is to explain differences in drunk driving across areas and to understand why some places experience higher levels of DUI enforcement than others. Toward this goal, this study examines how informal factors, such as normative climates toward drinking, and formal laws are related to variation in enforcement. In particular, focus is directed toward understanding whether differences in macro-level pro-drinking norms and anti-drinking norms are associated with levels of DUI enforcement and whether these informal factors exert effects independent of formal laws. To avoid inference of lower-level processes based on aggregate data, this study focuses on understanding macro-level factors that potentially account for macro-level variation or differences across aggregate units (i.e., counties).

BACKGROUND

Area-Wide Normative Climates

Norms are embedded cultural forces that provide rules about how people "ought" to behave—they prescribe, proscribe, and regulate social behavior (Hechter and Opp 2001; Homans 1961:12; Horne 2001). Sociologists have long argued that people take into account cultural and normative standards in deciding their own actions, and that the prevailing normative climate of an area can encourage or discourage types of behavior (Anderson 1999; Butler 2002; Jenks and Mayer 1990; Lee et al. 2007).

Alcohol is a feature of American culture, and groups in some areas define drinking as unacceptable while in other areas, drinking is acceptable, if not encouraged behavior. These general rules about alcohol consumption, including social prescriptions about acceptable usage (e.g., amount, type of beverage, time of day, place, social setting), are powerful cultural forces (Felson et al. 2011; Linsky et al. 1987; Room and Makela 2000). Thus, the widely held rules regarding alcohol create a framework from which group members and non-members evaluate themselves and their behavior, forming the basis of the normative climate in which they are enmeshed. For example, an observer of the French Quarter in New Orleans, Louisiana, the Las Vegas Strip, Nevada, or a major college town is likely to be aware of a normative climate where drinking is acceptable—just as a visitor to parts of Utah or areas of the South would experience a normative climate against drinking alcohol. The normative climate toward drinking is pervasive and one would be hard-pressed to ignore symbols regarding the cultural position of alcohol. In this way, the standards held by some groups can become a part of the normative system regulating social behavior, which is experienced by group members and non-members, including police.

It is well understood in criminological research and theory that arrest rates are in part a reflection of actual offending behavior and in part a reflection of arrest policies, policing strategies, and more generally, the behavior of social control agents (Black 1970; Mosher, Miethe, and Hart 2011; O'Brien 1996; Schwartz and Rookey 2008; Sutherland 1947). The seminal work of Wilson (1968) describes how police behavior is influenced by the relationship between the community political climate and the organizational characteristics and policies of the police department. For example, officers in a particular department may be expected to differentially enforce laws that are seen as important by community members and local officials but deemphasize enforcement of other types of criminal behavior, such as traffic violations (Wilson, 1968). Since detecting and arresting drunk drivers is a proactive and resource dependent policing practice, law enforcement agencies are likely to enforce DUI laws in response to community norms (Black 1970; Jacobs 1989). In areas where there is a strong normative climate against drinking, police agencies may use discretionary resources to engage in proactive practices to make DUI arrests. However, in other areas, police may be more tolerant of alcohol-related behaviors and reprioritize proactive policing efforts away from DUI patrols resulting in lower DUI arrest rates.

Religious groups and normative climates against drinking. Religion is a "bedrock institution" (Peterson, Krivo and Harris 2000), and religious culture is an important part of social life. The "moral communities" thesis (Stark, Kent, and Doyle 1982) suggests that rates of law breaking behavior will be *lower* where larger proportions of the population are actively religious (Lee 2006). According to this perspective, the widespread adherence to religion-based moral values in an area deter potential offenders from engaging in criminal (i.e., immoral) behavior (Lee 2006). Stark (1996) notes that this relationship can only be observed where populations are immersed in an area-wide environment of open religious

adherence and participation because the religious moral standards held by groups "enter into everyday interactions and become a valid part of the normative system" (Stark 1996:164).

Based on these insights, it is expected that the greater presence of certain religious groups, such as those who have strong moral commitments against drinking, is related to variation in levels of DUI enforcement by police. Religious affiliation is related to preferences toward alcohol consumption and alcohol restrictions (Chaloupka, Saffer, and Grossman 1993; Coate and Grossman 1988), and several religious groups have strong norms against alcohol consumption (e.g., Southern Baptists, Latter Day Saints, Evangelicals, and Seventh Day Adventists) (Nelson et al. 2004). The greater density of groups with strong "anti-drinking" norms in an area contributes to the moral climate that defines normative behavior, such as drinking. Since previous research suggests that these relationships may be limited to certain regions of the U.S. (Ellison, Burr, and McCall 2003; Lee 2006; Stark 1996), statistical controls for "South" and "rurality" are included in this analysis.

Widespread adherence to religion-based moral values concerning drinking may deter DUI behavior, but the enforcement of DUI laws may be increased because police are responsible for upholding the moral standards of the community in which they are members. Since detecting and arresting drunk drivers is a proactive and resource dependent policing practice (Black 1970; Jacobs 1989), law enforcement agencies operating in areas with strong proscriptive normative climates could be more likely to enforce DUI laws in response to community pressure for police action. Thus, it expected that in areas with normative climates against drinking, DUI enforcement will be greater, accounting for levels of DUI behavior and police force strength.

College campus areas and pro-drinking normative climates. The informal rules, values, and beliefs governing the use of alcohol are different among young adults compared to older age groups. Drinking alcohol marks a transition from youth to adulthood (Jacobs 1989) and drinking among young adults is a very common social practice (Harford, Wechsler and Seibring 2002). Studies show that about 40 percent of college-aged students are binge drinkers (Kuo et al. 2003; Wechsler et al. 2002), which is usually defined as heavy episodic alcohol consumption of at least five drinks in a row for men or four drinks in a row for women. While drinking appears to be more common among young adults, particularly young adult males (Roebuck and Murty 1996), there is considerable agreement in the empirical literature that young men and women comprise a disproportionate share of drunk drivers. Young adults are more likely than older age groups to self-report, get arrested for, or fatally injure someone while driving drunk (Mayhew et al. 2003; Schwartz and Rookey 2008; Zador, Krawchik, and Voas 2000). Even though increased drinking behavior and DUI behavior among young adults is expected to be related to greater DUI arrest rates, it is also likely that police enforcement of DUI laws vary in relation to the presence of a college campus.

College and university campuses are not only unique places that promote education, entertainment, and "college culture," but may also contribute to the climate that defines normative behaviors, such as drinking. Not only is drinking acceptable in a majority of these areas, but college campuses can provide the area with a wide range of resources and space for social interactions in which drinking norms are defined and redefined.

A large body of research shows higher rates of binge drinking and higher rates of alcohol consumption among college students (Hingson et al. 2002; Wechsler et al. 2002). Among a majority of college students, moderate drinking is a normative behavior (Presley, Meilman, and Lyerla 1995) and heavy drinking is common for certain subgroups of college students (i.e., sororities and fraternities) engaged in a "party subculture" (Hagan 1991). Pro-drinking attitudes compounded by the party subculture of college campuses may be associated with pro-drinking norms not only among students, but to the area as well (Ahern et al. 2008). A range of services and businesses that serve and support drinkers, including bars and liquor stores (Kuo et al. 2003), usually accompany campus areas. In this sense, the structural and cultural aspects of college campuses support pro-drinking norms.

Colleges and universities also provide social and cultural capital to larger areas. The normative component to supporting a nearby college or university reaches beyond local campuses into neighboring communities and the region. Specific contexts and events (e.g., football games) that promote drinking and help maintain pro-drinking norms are common at colleges and universities (Oster-Aaland and Neighbors 2007). These types of events amplify social interactions among groups within campus areas and from outside the campus (Neighbors et al. 2006). When groups come together in campus areas, normative interactions are more likely to take place among community members, students, and alumni at specific places including tailgating areas (Oster-Aaland and Neighbors 2007), local bars or taverns, or private parties, all of which protect pro-drinking norms.

Based on these aspects, the presence of a college campus contributes to the normative climate that defines normative behavior. Inasmuch as drinking is defined as acceptable behavior in these areas; we would expect areas with a major college campus to be associated with higher levels of drinking and perhaps drunk driving. However, police (including city, county, state, and campus) may be more tolerant of alcohol-related behaviors (e.g., fistfights, public intoxication, drunk driving) in these areas. Controlling for the proportion of young adults, DUI behavior, and police force strength, lower levels of police

enforcement of DUI laws may be observed in areas with pro-drinking normative climates, as measured by the presence of a major college campus.

Formal Legal Factors

Although driving a vehicle while intoxicated has long been against the law, the social definition of drunk driving has changed, and many groups (e.g., Mothers Against Drunk Driving) consider drunk driving to be morally reprehensible (Jacobs 1989; Ross 1992; Reinarman 1988). In contrast to norms against drinking, there are mores, or formal rules, against drunk driving that also involve the moral standards of society. When norms are made into laws, legal sanctions are imposed by the state, which is responsible for enforcement of these rules through the legal system and the police (Horne 2000).

The formal legal system features many laws, ordinances, and police practices aimed at reducing and deterring drunk driving. For example, general deterrence policies have involved increased sanctioning following DUI arrests through administrative license revocation, mandatory jail time (Ross 1992; Voas 1986), and increased fines (Jacobs 1989; Ross and Voas 1989), as well as efforts to increase the perceived certainty of arrest through roadside sobriety checkpoints and DUI saturation patrols. Other state-imposed DUI countermeasures have included laws against drinking alcohol in a vehicle (i.e., open-container laws) and efforts to reduce the geographical availability of alcohol. There is a large body of research describing a wide variety of formal DUI laws (see Jacobs 1989) and their effectiveness (see Eisenberg 2003). These formal factors are in place because drunk driving remains a problem that informal factors have been unsuccessful in eliminating.

Three important policies effectively increase the ability of police to detect drivers under the influence of alcohol. First, the primary enforcement of seat belt laws authorizes police to initiate a traffic stop and issue a citation if an occupant is observed traveling unbelted in a motor vehicle (Houston and Richardson 2006). This gives police greater purview to detect alcohol-impairment among drivers who would not otherwise encounter police. Second, open-container laws were established to prohibit possession and consumption of alcoholic beverages in the passenger areas of a motor vehicle (NHTSA 2004). While drinking alcohol in a vehicle does not necessarily indicate intoxicated driving, open container laws provide another avenue for police to detect drunk drivers. Third, the strength of the police force increases the possibility of a criminal event, like drunk driving, leading to an arrest (Mosher 2001). Police have responded to the cultural redefinition of drunk driving by prioritizing DUI enforcement (Jacobs 1989; Ross 1992; Schwartz and Rookey 2008) and engaging in proactive policing strategies (Ross 1992). Proactive policing is directly correlated with the allocation of police staff resources (Black 1970).

Laws and the legal system can compensate for the inadequacies of informal control (Schwartz 1954) but the legal system of formal controls also affects the informal enforcement of social rules (Posner 1996). Horne (2000) finds that the presence of a strong legal system may inhibit the effectiveness of informal sanctioning and deteriorate group interactions that provide the basis of informal social control. While the present research cannot address informal social control per se, it is important to understand whether macro-level normative climates toward drinking exert effects on drunk driving independent of formal laws and rules administered by the government through the legal system. Based on previous research, formal factors—particularly those related to increasing police ability to detect drunk driving—are expected to be related to variation in DUI enforcement. It may be that formal legal policies mitigate any observed association between informal factors and DUI enforcement, but it is important to understand whether this is the case.

DATA AND METHODS

Examining the extent that informal and formal factors account for variation in drunk driving enforcement requires data on DUI arrests, DUI behavior, police force strength, religious adherents, college campuses, age structure, rurality, and several formal laws. Because of the data required, counties are used as units of analysis. While there are noted disadvantages associated with county-level information and analysis, a main benefit is that a wide array of data is available on counties but not for other units of analysis such as cities, and neighborhoods. (Lee 2006). Unlike neighborhoods or communities, counties encompass the entire contiguous U.S. and allow the complete range of social landscapes to be examined (Nielsen and Alderson 1997). In addition, the social processes related to normative systems and the formal control of drunk driving are embedded in counties. Counties are not just population containers, but instead are important spaces where area wide social processes occur. Local governmental systems (i.e., jails, courts, public health resources) and some police agencies (i.e., county sheriff) operate at the county-level and many state economic, environmental, health, and social programs and are delivered through county-based offices (Lobao, Hooks, and Tickamyer 2007).

This study analyzes a cross-sectional dataset derived from several official sources including the Federal Bureau of Investigation (Uniform Crime Reporting Program), The Association of Religion Data Archives (TheARDA), Integrated Postsecondary Educational Data System (IPEDS), National Highway Traffic Safety Administration (Fatality Analysis Reporting System), Expenditure and Employment Data for the Criminal Justice System (CJEE),

Insurance Institute for Highway Safety, the Alcohol Policy Information System (APIS) (NIAAA 2007b), U.S. Department of Agriculture, and U.S. Census.

Dependent Variable

The measure of DUI enforcement is based on arrest statistics for driving under the influence (DUI) obtained from the Uniform Crime Reporting Program (UCR), which is disseminated by the Federal Bureau of Investigation (FBI 1999-2001). Because in any particular year a proportion of U.S. counties experience few DUI arrests, this variable is averaged over 3 years (1999-2001). The FBI compiles annual arrest data from monthly reports submitted by over 17,000 law enforcement agencies. DUI arrests in each county are expressed as a rate per 100,000 county population covered by agencies reporting arrests to the FBI including city police, county sheriffs and college campus police. DUI arrests made by state agencies in Vermont, Connecticut, and New Jersey were not allocated to counties in the original UCR data files. To include this information, arrests made by state agencies (e.g., highway patrol, state police) were allocated to each county based on county share of the state population. This method of adjusting for arrests by state police could yield more conservative results in population-based models. The "coverage indicator" variable provided in the UCR program data was used to identify counties where police agencies did not report DUI arrests (missing data) and counties where a "true zero" count of DUI arrests could be assigned (see Lynch and Jarvis 2008). Agencies in two states (Illinois and Florida) did not report DUI arrests to the FBI in the period and were excluded from this study.

Table 1. Variable Descriptions

Variable	Description	Mean	S.D.
DUI enforcement	Arrests per 100,000 population	554.13	323.63
Anti-alcohol religious groups	Alcohol prohibitionist religious adherents per 100,000 population	383.65	318.37
Major college campus	0 = No major college campus. Counties with a college campus are coded "one" and multiplied by the natural log of full-time student enrollment at the college or university.	.97	2.76
Young adults	Percent of population 18-29 years of age	19.73	5.55
Seat belt law	1 = Primary enforcement of safety belt law	.42	.49
Open-container law	1 = Conforms to federal guidelines	.54	.49
Police force strength	Full-time police officers per 100,000 population	121.71	74.95
DUI behavior	Traffic fatalities involving at least one legally-intoxicated driver per 100,000 population (18 yrs +)	10.23	12.24
Rurality	Urban-Rural continuum code (9= most rural, 1= most urban)	5.17	2.67
Land area	County land area in square miles	973.16	1336.26
South	1= county in Southern U.S. Census region	.46	.49

Independent Variables

Anti-alcohol religious groups. The measure of normative climates against drinking is based on information obtained from the *Religious Congregations and Membership in the United States, 2000* study collected by the Association of Statisticians of American Religious Bodies (ASARB) and distributed by the Association of Religion Data Archives. Anti-alcohol religious group density reflects the number of alcohol prohibitionist religious adherents per 100,000 population. Only alcohol-prohibitionist religions identified in previous research were included: Latter Day Saints, Seventh Day Adventists, Nazarenes, and Southern Baptist Convention (Nelson et al. 2004; Room and Makela 2000).

College campus areas. The measure of pro-drinking normative climates is based on the presence of a major college campus in a county. This information was obtained from the 2000 Integrated Post-Secondary Education Data System "Institutional Characteristics File" available from the National Center for Education Statistics (NCES 2000). Included are colleges and universities that offer at least a bachelor's degree (excluding all law schools, seminaries, vocational schools, and community colleges) and provide aid for student athletes in a football program. The decision to restrict non-football colleges and universities was guided by the increased likelihood of pro-drinking norms (e.g., a party subculture) among students and attendees from the area at "football schools." Note that doing so eliminated many branch campuses and commuter campuses. While there is no generally accepted and widely available measure of widespread drinking norms in college campus areas, this measure seemed intuitive. Thus, the initial measure of "college campus" includes 343 schools. However, there are 17 eligible campuses in the four states (Alaska, Florida, Hawaii, and Illinois) excluded from the study (described below) and are not included in the analysis. Consequently, there are a total of 326 counties with a major college campus (11.1% of all counties under examination). Counties without a major college or university campus are coded "zero" and counties with a major college campus are coded "one." Since it seems important to account for differences in school size, this dummy variable was multiplied by the natural log of full-time student enrollment at the largest college or university (Table 1). As a result, the college campus variable is weighted to simultaneously capture the presence of a campus and differences in the size of the campus. Under the current approach, a large campus area with 25,000 full-time students (e.g., University of Colorado at Boulder) would have a greater value than a campus with 4,000 full-time students (e.g., Western Oregon University).

Age. The measure of *young adults* represents the percent of 18-29 year olds residing in the county and was obtained from the U.S. Census Bureau (2000).

Formal factors. *Seat-belt laws* are coded "one" if state law allows primary enforcement of seat belt laws. In 2000, 1,232 counties in 16 states permitted law enforcement officers to initiate a traffic stop and cite a driver solely for not wearing a seat belt (Table 1). Information on *open-container laws* was gathered from the National Institute on Alcohol Abuse and Alcoholism's Alcohol Policy Information System (NIAAA 2007a). Open container laws are coded "one" if the state of the county conforms to federal open-container law standards (1,580 counties in 28 states) in 2000. The measure of *police force strength* comes from Expenditure and Employment Data for the Criminal Justice System (CJEE) maintained by the Bureau of Justice Statistics (BJS 2000). The CJEE data are based on official government reports and records, central data collection agencies, and mail surveys. Police force strength is measured as the number of full-time police officers with arrest powers working for city, county and state law enforcement agencies per 100,000 population (see Table 1).

Controls. The measure of *DUI behavior* comes from the *Fatality Analysis Reporting System* (FARS) distributed by the National Highway Traffic Safety Administration (NHTSA 1999-2001). The NHTSA has tracked all fatal traffic accidents, including those that involve alcohol since 1975. Many consider traffic fatality data to provide the most accurate information regarding relative levels and distributions of drunk driving because BAC data are derived from pharmacological blood tests on nearly all fatally injured drivers and many surviving drivers in fatal accidents (Schwartz and Rookey 2008). Based on blood-alcohol concentration (BAC) variables provided in the FARS data and state BAC limit law at the time of the accident (NIAAA 2007a), each driver was coded as legally intoxicated if the drivers BAC level exceeded the legal limit. The measure of drunk driving fatalities represents all legally intoxicated drivers involved in fatal traffic crashes per 100,000 population 18 years and older in each county (averaged over 1999-2001).

To account for the impact of *rurality*, "Beale codes" for each county were obtained from the Economic Research Service (ERS) of the U.S. Department of Agriculture and are included as control variables in the analysis. These nine "rural-urban continuum codes" are ordinal and form a classification system that distinguishes metropolitan counties by size and nonmetropolitan counties by level of urbanization and geographical proximity to metro areas (Butler and Beale 1994; ERS 2004). The *land area* of each county is included in U.S. Census geography files and was converted from square meters to square miles. Because this research takes a population-based approach, it is important to control for the geographic scope in which populations reside.

Excluded units. DUI arrest statistics (1999-2001) were unavailable from the FBI for all counties in two states (Florida n= 67 and Illinois n=102) and were

excluded from the analysis. Alaska (county equivalents including 15 boroughs, 11 census geography areas and municipalities) Hawaii (4 counties and 1 non-governmental unit) were excluded to limit the analysis to the continental U.S. Other areas, including District of Columbia, Shannon County South Dakota, Essex County Vermont, and five boroughs in New York City, were also excluded due to lack of data availability. Thus, the total number of counties under examination is 2,916.

Spatial Interrelationships

Spatial dependence takes place when the values of one unit are influenced or dependent on values of geographically proximate units. Tobler's enduring observation summarizes this point—"everything is related to everything else, but near things are more related than distant things" (Tobler 1970:236). In this study, there are theoretical and methodological motivations for examining and adjusting for spatial dependence. The role of spatial structures, such as highway transportation networks, residential patterns and growth, in combination with the spatial nature of drunk driving, may increase spatial dependence in rates of DUI enforcement between neighboring counties. It is possible that DUI enforcement depends on unobserved factors in proximate counties and spatial dependence arises from the unobservable latent variables that are spatially correlated (LeSage 1998). The presence of positive spatial autocorrelation results in a loss of information, which is related to greater uncertainty, less precision, and larger standard errors (Anselin 2005). Thus, additional steps must be taken in this research to examine and adjust for spatial autocorrelation.

Exploratory Spatial Data Analysis (ESDA) is used to analyze and present the distribution of key variables and to diagnose spatial dependence and autocorrelation (Messner et al. 1999). ESDA includes measures of global spatial autocorrelation (Moran's I) and Local Indicators of Spatial Association (LISA). In brief, Moran's I is a measure of *global* spatial autocorrelation and ranges in value from 0 to 1, where higher values indicate greater spatial clustering. The measure captures the extent of overall clustering that exists among all counties in the U.S. In contrast to Moran's I, LISA measures the extent of significant spatial clustering of similar values around each place (Oakley and Logan 2007). The LISA procedure identifies four types of localized clusters of significant spatial correlations—high values surrounded by other high values (High-High), low values surrounded by other low values (Low-Low), low values surrounded by high values (Low-High), and high values surrounded by low values (High-Low).

ANALYTIC STRATEGY

Analysis of these data proceeds in three main steps. *First*, Exploratory Spatial Data Analysis (ESDA) is presented to show the spatial characteristics of key factors across U.S. counties. ESDA is an advantageous first step in examining and diagnosing spatial dependence and spatial autocorrelation among units of analysis. *Second*, bivariate analyses will assess inter-item correlations among measures. Bivariate correlation coefficients preview expected relationships and is a required step in diagnosing collinearity among independent variables. *Third*, after a series of spatial regression diagnostic tests to determine which spatial regression technique is best suited (see Anselin 2005; Baller et al. 2001), several spatial error regression models are presented to compare the effects of informal and formal factors on DUI enforcement.

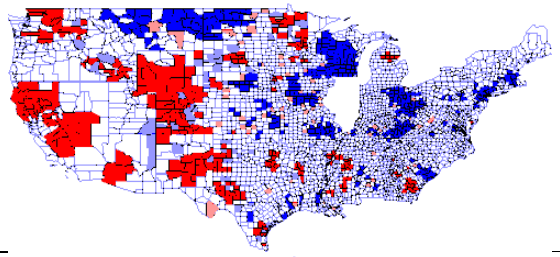
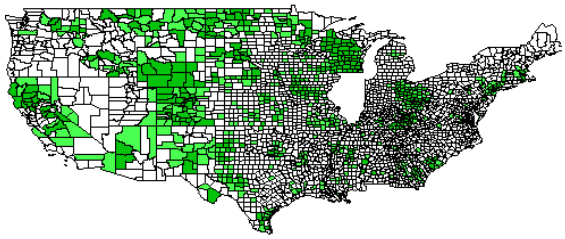
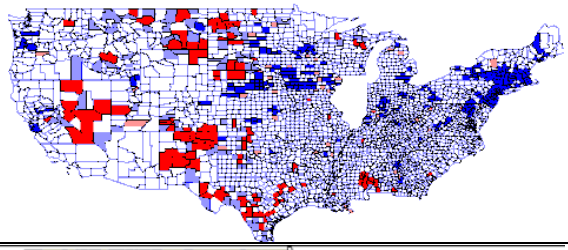
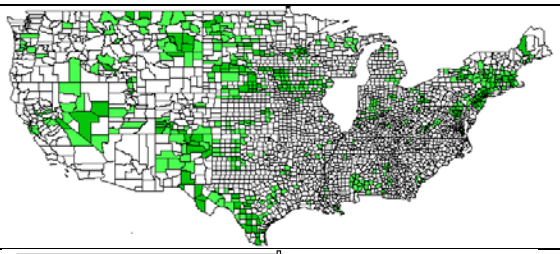
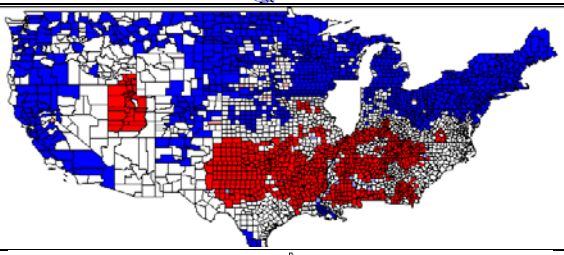
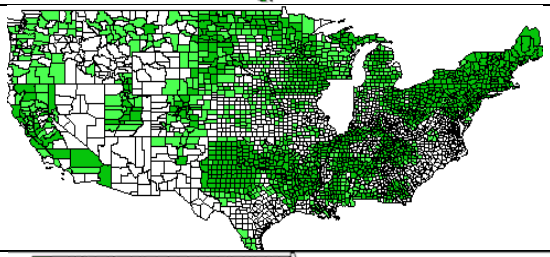
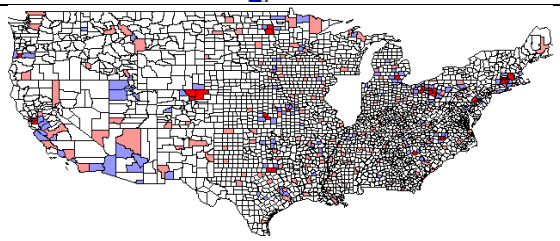
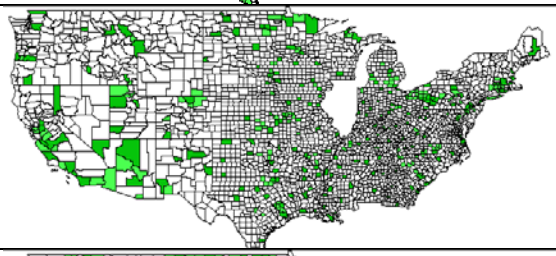
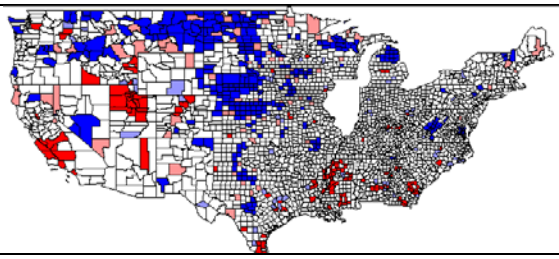
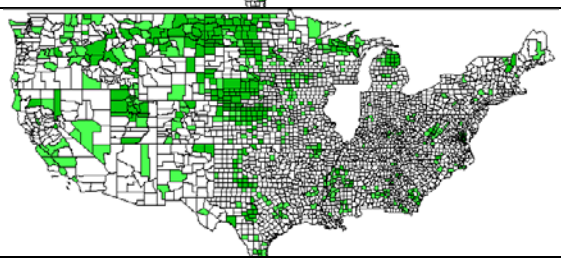
RESULTS

Univariate Analysis: Exploratory Spatial Data Analysis (ESDA)

Univariate spatial data analysis results show the uneven distribution of *enforcement of DUI laws (arrest)* (see Figure 1). The global Moran's I of .28 suggests low to moderate spatial clustering of counties experiencing similar levels DUI enforcement. Significant high-high clusters (high rates surrounded by high rates) of counties are observed in the regions of the west and low-low clusters (low rates surrounded by low rates) are observed in the north plains and areas of the Great Lakes region. While these results show that global spatial autocorrelation of DUI rates among counties is not particularly high, the extent of local spatial autocorrelation (LISA) suggests that adjustments for spatial autocorrelation are necessary in regression analysis. That is, the visual representation of the distribution and indicators of global and local spatial association of DUI enforcement confirms the diagnostic test results that spatial autocorrelation is present among counties in the United States.

As shown in Figure 1, the LISA and global measures of spatial autocorrelation (Moran's I = .799) show that there is considerable clustering of anti-alcohol religious groups across counties in the U.S. The LISA cluster map shows high spatial clustering of counties with high rates of anti-alcohol religious adherents surrounded by other high-rate counties, particularly in the South and areas of Utah and southern Idaho. This suggests that areas where normative climates against drinking are strong tend to be located near similar communities.

Figure 1. Global Moran's I and Local Indicators of Spatial Autocorrelation (LISA)

Variable (Moran's' I)	**LISA Cluster Map**	**LISA Significance Map**
DUI enforcement (.280)		
DUI behavior (.110)		
Anti-alcohol religious groups (.799)		
Major college campus (.015)		
% Young adult (.168)		
Legend (0-1.00)	Not Significant High-High Low-Low Low-High High-Low	Not Significant p = 0.05 p = 0.01 p = 0.001 p = 0.0001 (999 permutations)

Bivariate Analysis: Correlations

Results of univariate ESDA visually suggest that levels of drinking places and anti-alcohol religious groups are spatially clustered in the South, which is consistent with previous research by Stark (1996). These results support an analysis of bivariate correlations, presented in Table 2. There is a moderate positive correlation (r =.637, p <.05) between anti-alcohol religious groups and the South. Based on this information, it seems important to include a statistical control for "South" in regression analyses. There is a weak positive correlation between the density of anti-alcohol religious groups and both DUI enforcement (r = . 074, p <.05), and in general, it appears that the correlations between the each informal measure and DUI enforcement are weaker than for the measures of formal factors.

Table 2. Bivariate Correlation Matrix

		1	2	3	4	5	6	7	8	9	10
1	DUI enforcement	…									
2	Anti-alc religious	.074*	…								
3	Major college campus	.011	-.086*	…							
4	Young adults	.123*	.065*	.511*	…						
5	Seat belt laws	.118*	.145*	-.022	.077*	…					
6	Open container laws	-.110*	-.311*	.042*	-.095*	-.095*	…				
7	Police force strength	.194*	.027	-.091*	-.118*	-.019	-.088*	…			
8	DUI behavior	.089*	.071*	-.120*	-.100*	.004	-.109*	.222*	…		
9	Rurality	-.002	.112*	-.255*	-.346*	-.143*	.037*	.137*	.231*	…	
10	Land area	.132*	-.119*	.024	-.015	-.039*	.071*	.089*	.145*	.078*	…
11	South	.059*	.637*	-.017	.178*	.246*	-.440*	.026	.070*	-.086*	-.253*

* Correlation coefficient is significant at the p < .05 level (two-tailed test).

Multivariate Analysis: Spatial Regression Models

Based on results from tests of spatial dependence, factor analysis (Principle Components) and Ordinary Least Squares (OLS) regressions (not shown), results from *spatial error models* are presented (see Baller et al. 2001). The formal expression of the spatial error regression model here is $y = X\beta + \varepsilon$, with $\varepsilon = \lambda W\varepsilon + u$, where y is a vector of observations on the dependent variable, *W* is the spatial weights matrix (i.e., row-standardized queens contiguity) on the explanatory variables, ε is a vector of spatially autocorrelated error terms, *u* a vector of independent and identically distributed (IID) errors, and λ and β are parameters (Anselin 2005).

Consistent with expectations, greater presence of anti-alcohol religious groups is associated with increased DUI enforcement (m1, β=.048, p<.05), but the effect falls from statistical significance when controlling for the South as shown in (Table 3, model 2). When other informal factors and formal factors (i.e., seat belt law, open-container law, and police force strength) are included, the effect of anti-alcohol religious groups (m6: β = .055, p<.05) is positive and statistically significant on DUI enforcement while controlling for South. The effect of college campus (m3: β = .036, p<.05) is positive and statistically significant on DUI enforcement when the measure of young adults is absent from the model. However, the effect (β = -.032, p<.05) is negative and statistically significant when young adults enters the model. The effect of young adults is positive and statistically significant when considered alone (m4: β = .127, p<.001), with major college campus (m5: β = .145, p<.001) and with anti-alcohol religious groups (m6: β = .147, p<.001).

In all models, primary enforcement of seat belt laws (β = .101, p<.001) and police force strength (β = .205, p<.001) are associated with higher levels of DUI enforcement and open-container laws are associated with decreased DUI enforcement (β = -.075, p<.01). A greater proportion of the total explained variance in DUI enforcement is attributed to formal factors compared to informal factors. The coefficient for the spatial autoregressive term (λ) is positive and statistically significant. Inclusion of the spatial autoregressive coefficient in these models reduces bias in standard errors and improves the accuracy of results.

Table 3. The Effects of Selected Informal and Formal Factors on DUI Enforcement (Arrest Rates), Spatial Error Regression. n=2916.

	1		2		3		4		5		6		Proportion of total variance
	b	β	b	β	b	β	b	β	b	β	b	β	
INFORMAL:													
Anti-alc religious	.048*	.047	.043	.042	…		…		…		.055*	.054	.0014
	(.026)		(.030)								(.029)		
Major college campus	…		…		4.273*	.036	…		-3.739*	-.032	-3.513*	-.030	.0013
					(1.938)				(2.243)		(.245)		
FORMAL:													
Seat belt law p.e.	67.351***	.103	66.193**	.101	67.730***	.103	67.240***	.103	65.909***	.101	66.215***	.101	.0110
	(17.935)		(18.259)		(18.336)		(18.087)		(18.072)		(18.038)		
Open-container law	-53.028**	-.082	-50.992**	-.078	-52.598**	-.081	-50.396**	-.078	-49.303**	-.076	-48.612**	-.075	.0041
	(18.095)		(19.064)		(19.123)		(18.881)		(18.860)		(18.829)		
Police force strength	.835***	.193	.835***	.193	.839***	.194	.878***	.203	.879***	.204	.884***	.205	.0321
	(.083)		(.082)		(.082)		(.081)		(.081)		(.081)		
CONTROLS:													
Young adults	…		…		…		7.421***	.127	8.464***	.145	8.539***	.147	.0177
							(1.045)		(1.217)		(1.217)		
DUI behavior (fatalities)	.667	.025	.659	.025	.714	.027	.825*	.031	.790*	.030	.812*	.031	.0007
	(.462)		(.463)		(.463)		(.460)		(.460)		(.460)		
Rurality	-7.479**	-.062	-7.386**	-.061	-5.720*	-.047	-1.763	-.015	-2.011	-.017	-2.669	-.022	.0001
	(2.643)		(2.659)		(2.674)		(2.697)		(2.699)		(2.720)		
Land area	.018***	.074	.018***	.074	.017**	.070	.016**	.066	.016**	.066	.016**	.066	.0128
	(.005)		(.005)		(.005)		(.005)		(.005)		(.005)		
South	…		8.351	.013	24.923	.038	10.948	.017	9.401	.014	-12.765	-.020	.0006
			(24.313)		(21.340)		(21.148)		(21.124)		(24.165)		
λ	.462***		.463***		.466***		.462***		.461***		.459***		
	(.023)		(.023)		(.023)		(.023)		(.023)		(.023)		
Constant	449.135***		445.921***		441.862***		280.059***		265.108***		254.514***		
	(25.408)		(27.146)		(27.272)		(35.949)		(37.002)		(37.383)		
R^2	.220		.220		.222		.233		.234		.234		
ll	-20693		-20693		-20692		-20669		-20668		-20666		

Note: *p≤.05; ** p≤.01; ***p≤.001 (one-tailed test). Standard errors in parentheses.

DISCUSSION AND CONCLUSION

This research set out to explain macro-level differences in DUI enforcement across areas by examining how a set of informal factors, such as normative climates toward drinking, and a limited set of formal legal factors are related to levels of DUI enforcement across counties. It was unclear whether "informal factors" (i.e., non-legal factors) exert effects on DUI enforcement independent of formal legal factors, such as seat belt laws, open container laws and police force strength. Results suggest that informal factors do appear to account for some of the variation in the enforcement of drunk driving independent of the formal factors measured in this research. In particular, DUI enforcement, which is in part an indicator of offending behavior and also a measure of law enforcement behavior, seems to vary in relation to normative climates toward drinking, controlling for police force strength and DUI behavior.

Consistent with expectations, there tends to be higher rates of DUI enforcement by police where the normative climate towards drinking contains strong *anti-drinking* norms. That is, law enforcement agencies appear to make higher levels of DUI arrests per population in areas with a strong normative climate against drinking. Conversely, areas with a normative climate that defines drinking as acceptable behavior are associated with lower rates of DUI enforcement. Together these findings suggest that police behavior in enforcing DUI laws is related to area-wide normative climates toward drinking.

Overall, these findings suggest that to understand variation in the enforcement of DUI it is useful to account for normative climates of an area. While it is common for statistical models predicting arrest rates to include controls for cultural differences by including a variable for the South or age structure of the population, it seems important to consider widely held cultural norms that influence police enforcement and behavior. Research on the relationship between religious cultural norms and crime rates suggests that strong normative climates, where religion-based moral standards enter into the normative system, are characteristic of the Southern United States. In this study, the effect of anti-alcohol climates has a positive and statistically significant effect on rates of DUI enforcement while controlling for the South. This suggests that the relationship between normative climates against drinking and DUI enforcement is not limited to areas in the South.

Results also suggest that some of the variation in DUI enforcement by police across areas is also related to *pro-drinking* normative climates. That is, areas where the normative climate defines drinking as acceptable behavior tend to be associated with lower rates of DUI enforcement. In this research, pro-drinking normative climates are measured as the "weighted" presence of a major college campus in the area, where a dummy variable indicating the presence of a main campus is multiplied by logged student enrollment at the school. Controlling for the proportion of young adults, DUI enforcement tends to be lower in areas where there is a greater college campus presence. While the normative climate is generally accepting of drinking among young adults, the greater presence of a college campus appears to be a protective factor in the enforcement of DUI laws. This finding may provide some support for the assertion that many college campuses have an impact on the community and the behavior of law enforcement agencies in the area (including city, state, and campus police agencies).

One explanation of this relationship is that DUI enforcement by police differs in relation to the pro-drinking normative climate through less intensive enforcement of alcohol-related problems. In areas where drinking behavior does not conflict with the normative climate, police from various law enforcement agencies may be more tolerant of drinking-related behavior. Unlike areas with strong widely-held norms against drinking, police may not experience a similar level or type of community pressure to address drunk driving through proactive policing. However, counties with major college campuses could be more amiable to alternative forms of transportation. The dense residential patterning (e.g., more dormitories, apartments, and multi-unit dwellings) and more extensive local services, including drinking places where customers can purchase and consume alcohol in campus counties, may result in lower levels of DUI behavior (Mosher and Akins 2007; Ross 1992). While the use of counties as units of analysis in this study does not allow these factors to be measured, future research at the city-level would help us understand how campus-area transportation structures, residential patterning, and the spatial patterning of businesses (including drinking places) relate to rates of drunk driving enforcement and norms concerning drinking.

The formal legal system features many laws, ordinances, and police practices aimed at reducing and deterring drunk driving. Even though the formal laws considered in this research are enacted at the state level, there is within-state variation in the enforcement of laws that may help account for differences in DUI enforcement across counties. A goal of this research was to examine the extent to which informal factors exert effects on rates of DUI enforcement independent of formal factors. Results suggest the informal factors related to the normative climate regarding drinking are related to DUI enforcement independent of formal legal factors. While the set of informal factors (i.e., non-legal factors) account for some variation, formal factors explain a greater proportion of the variance in DUI enforcement than is explained by informal factors. These findings are not unexpected because as Jacobs (1989) suggests, the social control of drunk driving behavior remains heavily

dependent on "governmental initiatives" and less on non-legal informal factors.

It is important to note that this research has only considered a limited set of state-wide laws aimed at reducing or deterring drunk driving behavior. While several additional laws (e.g, dram shop liability, social host liability, mandatory ignition locks and administrative license revocation for convicted drunk drivers) have been adopted by some states, the laws included in this research are sufficient in representing differences in legal factors that increase police ability to detect and arrest drinking drivers among county populations. Moreover, it is important to recognize that using state-level measures of formal laws has negative implications when included in linear regression models. A state-level measure in a county-level analysis violates the assumption of independent errors because counties are spatially clustered in states—leading to biased standard errors (Fullerton, Wallace, and Stern 2009). Multilevel modeling techniques could adjust for these problems by allowing for separate error terms at the county-level and state-level. However, the spatial regression techniques used here adjust for spatial dependencies among counties (also violating the assumption of independence) by including a spatially lagged error term in the regression models. Therefore, accounting for spatial dependencies between counties seemed of foremost importance as rates of DUI enforcement are influenced by factors in surrounding counties.

While the use of counties as units of analysis has several distinct advantages in this research, there are several implications for the interpretation and utility of results. A potential limitation of this research concerns the assumption that normative climates toward drinking are measurable—particularly at the county-level. While previous research has measured county-level variation in moral climates by the density of religious adherents per population (Lee 2006), it is quite possible "climates" are not accurately measured by the greater presence of groups holding certain cultural values and beliefs. The rationale behind the measurement of normative climate towards drinking relies on assumptions that these groups actually hold strong norms concerning drinking and the greater representation of the relevant group represents variation in the strength of the normative climate in the area. While much literature suggests that people take into account cultural and normative standards in deciding their own actions, the findings of this research can be called into question if these assumptions are incorrect.

In addition, informal social and political climates, organizational characteristics of police departments, as well as local alcohol ordinances, occur at the city-level (and multi-city agglomerations). When counties are used as units of analysis, local factors that are also likely to influence patterns of DUI enforcement are not directly measured. Similarly, studies employing administrative and statistical areas (e.g., zip code tabulation areas, census tracts, and census blocks) consistently confront the modifiable areal unit problem where results may differ depending on how populations are parceled in space (Irwin 2007). In this study, it is important to recognize that the effects of factors that are specific to smaller areas, such as cities or neighborhoods, may be less intense when observed at the county-level. Future research should be conducted to understand how additional formal factors, such as local alcohol ordinances, police resources, and informal factors, such as social and political climates, influence DUI enforcement by local police departments at the sub-county level. Since counties are important spaces where many governmental processes are carried out (i.e., jails, courts, public health) (Lobao, Hooks, and Tickamyer 2007), future research should also employ multilevel statistical techniques to simultaneously analyze data collected at multiple levels (i.e., cities and counties) to better understand how macro-level contexts influence individual offending behavior and police behavior in enforcing laws.

Criminologists should continue to explain how normative climates influence the enforcement of laws and affect the patterning of alcohol-related crime. Efforts to understand how offense-specific normative climates (e.g., normative climates against DUI) affect rates of behavior could yield important information for developing more effective control policies. In the case of drunk driving, criminologists and policy makers should work to increase the strength of anti-drunk driving norms so that DUI control efforts, as Jacobs (1989) suggests, "would not be so dependent on governmental initiatives and could rely on less intrusive, informal interpersonal controls and on personal choices and inhibitions" (195).

Jacobs (1989) argues that the long-term goal of controlling DUI should involve a wide-scale internalization of anti-DUI norms, which would rely on informal social controls and not depend so much on formal policies. The results of this cross-sectional research (based on 1999-2000 data) suggest that while formal laws and official policies explain some of the differences in DUI, normative climates toward drinking also help account for differences in DUI enforcement across areas. Future research should investigate whether the strength of normative climates concerning drinking, and perhaps more importantly drunk driving, has increased over time and recommend long-term strategies to increase conformity to anti-DUI norms across the general population. Efforts to increase the widespread internalization of anti-DUI norms would require a large amount of resources, but in the long-term, vast savings could be realized as effective control of DUI would necessitate less allocation of official resources than are used today.

Endnotes

[1] Multicollinearity is a persistent problem in macro-level research because many basic population characteristics are strongly intercorrelated. Multicollinearity can inflate standard errors for regression coefficients leading to unstable parameter estimates. Additional regression diagnostics tests were conducted (not presented) to inspect for multicollinearity. An analysis of variance inflation factor values (VIF) indicated that no VIF value for variables in any model exceeded 2.19 (South), suggesting that multicollinearity is not a serious concern among independent variables. Because the measure of college campus area is related to age structure (r = .511), it was suspected that collinearity would be problematic in models containing both measures. However, VIF value for age structure is 1.52 and 1.40 for college campus, among the full set of independent variables.

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